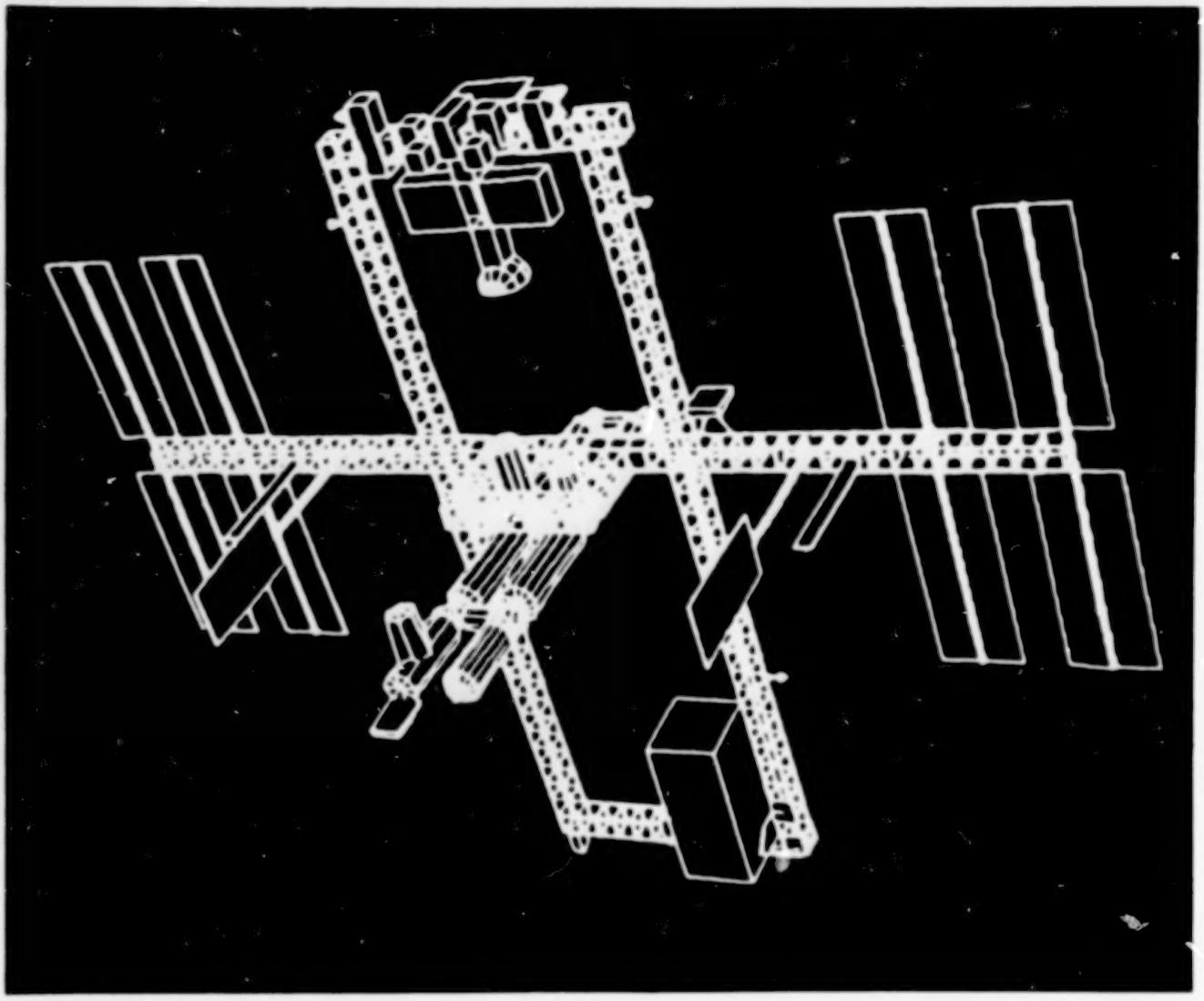
NAS 1.21:7055/Supp 7

NASA

Space Station Systems

A Bibliography
with Indexes

NASA SP-7055 (07)
December 1988



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NASA SP-7056 (07)

SPACE STATION SYSTEMS

A BIBLIOGRAPHY WITH INDEXES

Supplement 7

Compiled by
Technical Library Branch
and
Edited by
Space Station Office
NASA Langley Research Center
Hampton, Virginia

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system between January 1 and June 30, 1988 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

NASA
Scientific and Technical Information Division 1988
National Aeronautics and Space Administration
Washington, DC

NOTE TO AUTHORS OF PROSPECTIVE ENTRIES:

The compilation of this bibliography results from a complete search of the *STAR* and *IAA* files. Many times a report or article is not identified because either the title, abstract, or key words did not contain appropriate words for the search. A number of words are used, but to best insure that your work is included in the bibliography, use the words *Space Station Systems* somewhere in your title or abstract, or include them as a key word.

This supplement is available from the National Technical Information Service (NTIS), Springfield , Virginia 22161 at the price code A13.

INTRODUCTION

This bibliography is designed to be helpful to the researchers, designers, and managers engaged in the design and development of technology, configurations, and procedures that enhance efficiencies of current and future versions of a Space Station.

This literature survey lists 1,158 reports, articles and other documents announced between January 1, 1988 and June 30, 1988 in *Scientific and Technical Aerospace Reports (STAR)*, and *International Aerospace Abstracts (IAA)*.

The coverage includes documents that define major systems and subsystems, servicing and support requirements, procedures and operations, and missions for the current and future Space Station. In addition, analytical and experimental techniques and mathematical models required to investigate the different systems/subsystems and conduct trade studies of different configurations, designs, and scenarios are included. A general category completes the list of subjects addressed by this document.

The selected items are grouped into categories as listed in the Table of Contents with notes regarding the scope of each category. These categories were especially selected for this publication and differ from those normally found in *STAR* and *IAA*.

Each entry consists of a standard bibliographic citation accompanied by an abstract, where available, and appears with the original accession numbers from the respective announcement journals.

Under each of the categories, the entries are presented in one of two groups that appear in the following order:

(1) *IAA* entries identified by accession number series A88-10,000 in ascending accession number order;

(2) *STAR* entries identified by accession number series N88-10,000 in ascending accession number order.

After the abstract section there are seven indexes—subject, personal author, corporate source, foreign technology, contract number, report number, and accession number.

A companion continuing bibliography, *"Technology for Large Space Structures,"* is available as NASA SP-7046.

Robert E. Satterthwaite, *Space Station Office*
Sue K. Seward, *Technical Library Branch*

TABLE OF CONTENTS

Page

Category 01 Systems 1

Includes system requirements for proposed missions, mission models, overall conceptual configuration and arrangement studies; systems analyses for future required technology; and identification and description of technology developments and experiments for the elements of a complete Space Station system.

Category 02 Models, Analytical Design Techniques, and Environmental Data 7

Includes descriptions of computerized interactive systems design and development techniques, computer codes, internal and external environmental models and data.

Category 03 Structural Concepts 10

Includes analyses and descriptions of different Space Station structural concepts, arrangements, testing, methods of construction and/or manufacturing and specific rotary joints, structural nodes, and columns.

Category 04 Thermal Control 32

Includes descriptions of analytical techniques, passive and active thermal control techniques, external and internal thermal experiments and analyses and trade studies of thermal requirements.

Category 05 Environmental Control and Life Support Systems 38

Includes description of analytical techniques and models, trade studies of technologies, subsystems, support strategies, and experiments for internal and external environmental control and protection, life support systems, human factors, life sciences and safety.

Category 06 Dynamics and Controls 47

Includes descriptions of analytical techniques and computer codes, trade studies, requirements and decriptions of orbit maintenance systems, rigid and flexible body attitude sensing systems and controls such as momentum wheels and/or propulsive schemes.

Category 07 Power 62

Includes descriptions of analyses, systems, and trade studies of electric power generation, storage, conditioning and distribution.

Category 08 Electronics 75

Includes descriptions of analytical techniques, analyses, systems, and requirements for internal and external communications, electronics, sensors for position and systems monitoring and antennas.

Category 09 Propulsion/Fluid Management 77

Includes descriptions, analyses, and subsystem requirements for propellant/fluid management, and propulsion systems for attitude control and orbit maintenance and transfer for the station and supporting elements such as the OMV and OTV.

Category 10 Mechanisms, Automation, and Artificial Intelligence 81

Includes descriptions of simulations, models, analytical techniques, and requirements for remote, automated and robotic mechanical systems.

Category 11 Materials 94

Includes mechanical properties of materials, and descriptions and analyses of different structural materials, films, coatings, bonding materials, and descriptions of the effects of natural and induced space environments.

Category 12 Information and Data Management **98**
Includes descriptions, requirements, and trade studies of different information and data system hardware and software, languages, architecture, processing and storage requirements for managing and monitoring of different systems and subsystems.

Category 13 Accommodations **102**
Includes descriptions of simulations, analyses, trade studies, and requirements for safe efficient procedures, facilities, and support equipment on the ground and in space for processing, servicing, verification and checkput of cargo and equipment.

Category 14 Growth **104**
Includes descriptions of scenarios, analyses and system technology requirements for the evolutionary growth of the Space Station system.

Category 15 Missions, Tethers, and Platforms **107**
Includes descriptions and requirements of missions and tothers onboard the Space Station and platforms that are either co-orbiting with the Space Station, in polar orbit, or in geosynchronous orbit and which are part of the Space Station system.

Category 16 Operations Support **121**
Includes descriptions of models, analyses and trade studies of maneuvers, performance, support, and EVA and/or IVA servicing requirements of Space Station systems such as the OMV and OTV, and experiments.

Category 17 Space Environment **129**
Includes description of the space environment and affects on Space Station subsystems. Includes requirements of Space Station to accommodate this environment.

Category 18 International **132**
Includes descriptions, interfaces and requirements of international payload systems, subsystems and modules considered part of the Space Station system and other international Space Station activities such as the Soviet Salyut.

Category 19 Support Spacecraft **149**
Includes design, analysis, requirements, trade studies and simulations of Space Station support spacecraft including the orbital transfer vehicle (OTV) and the orbital maneuvering vehicle (OMV).

Catefory 20 Life Sciences/Human Factors/Safety **151**
Includes studies, models, planning, analyses and simulations for biological and medical laboratories, habitability issues for the performance and well-being of the crew, and crew rescue.

Category 21 General **159**
Includes descriptions, analyses, trade studies, commercial opportunities, published proceedings, seminars, hearings, historical summaries, policy speeches and statements that have not previously been included.

Subject Index **A-1** 169
Personal Author Index **B-1** 224
Corporate Source Index **C-1** 253
Foreign Technology Index **D-1** 263
Contract Number Index **E-1** 267
Report Number Index **F-1** 269
Accession Number Index **G-1** 273

TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED
ON MICROFICHE
ACCESSION NUMBER
N88-13907*# Catholic Univ. of America, Washington, D.C. Dept. of Electrical Engineering
CORPORATE SOURCE
TITLE
OPTIMAL CONTROL OF LARGE SPACE STRUCTURES VIA GENERALIZED INVERSE MATRIX
PUBLICATION DATE
AUTHORS
CHARLES C. NGUYEN and XIAOWEN FANG 1987 5 p
CONTRACT NUMBER
(Contract NAG5-949)
REPORT NUMBERS
(NASA-CR-182336; NAS 1.26:182336) Avail: NTIS HC A02/MF A01; CSCL 09B
AVAILABILITY SOURCE
COSATI CODE
Independent Modal Space Control (IMSC) is a control scheme that decouples the space structure into n independent second-order subsystems according to n controlled modes and controls each mode independently. It is well-known that the IMSC eliminates control and observation spillover caused when the conventional coupled modal control scheme is employed. The independent control of each mode requires that the number of actuators be equal to the number of modelled modes, which is very high for a faithful modeling of large space structures. A control scheme is proposed that allows one to use a reduced number of actuators to control all modeled modes suboptimally. In particular, the method of generalized inverse matrices is employed to implement the actuators such that the eigenvalues of the closed-loop system are as closed as possible to those specified by the optimal IMSC. Computer simulation of the proposed control scheme on a simply supported beam is given. Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED
ON MICROFICHE
ACCESSION NUMBER
A88-28043*# California Univ., Los Angeles.
TITLE
CONTROL-AUGMENTED STRUCTURAL SYNTHESIS
AUTHORS
R. V. LUST and L. A. SCHMIT (California, University, Los Angeles) AIAA Journal (ISSN 0001-1452), vol. 26, Jan. 1988, p. 86-95. refs
AUTHOR'S AFFILIATION
JOURNAL DATE
JOURNAL TITLE
CONTRACT NUMBER
(Contract NSG-1490)
(AIAA PAPER 86-1014)
A control-augmented structural synthesis methodology is presented in which the structural member sizes and active control system feedback gains are treated simultaneously as independent design variables. Multiple static and harmonic dynamic loading conditions are considered. Constraints are imposed on static displacements, natural frequencies, and the magnitudes of the steady-state dynamic displacements and actuator forces to ensure acceptable system behavior. Side constraints imposed on the design variables protect against the generation of unrealizable designs. Example problems are presented that demonstrate the method and underscore the importance of integrating the structural and active control system design process. Author

SPACE STATION SYSTEMS

A Bibliography (Suppl. 7)

DECEMBER 1988

01

SYSTEMS

Includes system requirements for proposed missions, mission models, overall conceptual configuration and arrangement studies; systems analyses for future required technology; and identification and description of technology developments and experiments for the elements of a complete Space Station system.

A88-10155* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION VIEWING REQUIREMENTS
FRANCES E. MOUNT and JAMES L. LEWIS (NASA, Johnson Space Center, Houston, TX) IN: Aerospace Behavioral Engineering Technology Conference, 5th, Long Beach, CA, Oct. 13-16, 1986, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 41-43.
(SAE PAPER 861754)

Concern based on historical precedent led to early investment of resources to identify Space Station viewing requirements in order that they could be transferred to module window designs, cupolas, indirect viewing methods (e.g., closed circuit television), and implemented in cost models tracking overall station configuration weight and cost. Previous space history and earth based analogs were used to identify needs and requirements relevant to long term missions. Author

A88-13126
ADVANCED MATERIALS TECHNOLOGY '87; PROCEEDINGS OF THE THIRTY-SECOND INTERNATIONAL SAMPE SYMPOSIUM AND EXHIBITION, ANAHEIM, CA, APR. 6-9, 1987
RALPH CARSON, ED., MARTIN BURG, ED., KENDALL J. KJOLLER, ED., and FRANK J. RIEL, ED. Symposium and Exhibition sponsored by SAMPE. Covina, CA, Society for the Advancement of Material and Process Engineering (Science of Advanced Materials and Process Engineering Series. Volume 32), 1987, 1623 p. For individual items see A88-13127 to A88-13239.

The present conference on advanced materials considers topics in the fields of novel bismaleimide resin systems, USAF Materials Laboratory technology-development forecasts, high performance thermoplastics, ceramic-matrix composites, high temperature thermosetting resins, pressure-sensitive adhesives, advanced filament-winding methods, metal-matrix composites, and impact damage tolerance and control in filament-wound structures. Also discussed are spacecraft materials applications, epoxy resin technology, automated materials processing equipment, asbestos-substitute fibers, thermally hardened electronic materials, carbon/carbon composites, and pultrusion technology. O.C.

A88-15314* Teledyne Brown Engineering, Huntsville, Ala.
POLYMER CRYSTAL GROWTH FACILITY CONCEPT FOR SPACE STATION LABORATORY MODULE
TRIPTY MOOKHERJI and RAYMOND MOORE (Teledyne Brown Engineering, Huntsville, AL) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 7 p.
(Contract NAS8-36122)

Interest in materials processing in space began to evolve in the late 1950's through low gravity simulation and some experiments on Apollo flights. Encouraged by the early results and considerations of the likely behavior of liquids and solidification process in low-gravity gave the recognition that this environment might be useful for a variety of unique processes. This generated a number of experimental ideas and gave rise to the design and development of facilities that will perform the experiments in space vehicles. These include the evolution of apparatus leading to the development of facilities for processing of materials on Skylab and now for the Space Transportation System (STS). The U.S. module on Space Station (SS) is going to expand this unique laboratory environment with practically no constraint on materials processing activity. This will need technology advancement for the hardware that will be required in this era. This presentation discusses the current concept for the experimental facility which will be housed in the U.S. Laboratory module on the Space Station and will allow the growth of single crystals of polymeric and organic materials using the state-of-the-art growth techniques. Author

A88-15801#
THE INDUSTRIAL SPACE FACILITY
MAXIME A. FAGET and C. C. JOHNSON (Space Industries, Inc., Houston, TX) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 6 p.
(IAF PAPER 87-01)

The design and operational capabilities of the Industrial Space Facility (ISF), a man-tended space platform that is to be placed on the Space Station, are described. The ISF is composed of two types of modules: facility modules and auxiliary modules. The facility is to operate in a circular orbit inclined 28.5 deg at orbital altitudes ranging from 160-220 nm and is to provide about 10 kW of power and cooling and telemetry capabilities. The ISF is to be used primarily for research and manufacturing of materials, and its modular design will permit easy growth to meet additional service and power demands. The initial deployment sequence and the servicing mission to resupply the ISF are discussed. Diagrams of the ISF and its modules are provided. I.F.

A88-15832*# National Aeronautics and Space Administration, Washington, D.C.
PATHFINDER TECHNOLOGIES FOR BOLD NEW MISSIONS
STANLEY R. SADIN and ROBERT ROSEN (NASA, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 6 p.
(IAF PAPER 87-46)

Project Pathfinder is a proposed U.S. Space Research and Technology program intended to enable bold new missions of space exploration. Pathfinder continues the advancement of technological capabilities and extends the foundation established under the Civil Space Technology Initiative, CSTI. By filling critical technological gaps, CSTI enhances access to Earth orbit and supports effective operations and science missions therein. Pathfindor, with a longer-term horizon, looks to a future that builds on Shuttle and Space Station and addresses technologies that support a range of exploration missions including: a return to the Moon to build an outpost; piloted missions to Mars; and continued scientific exploration of Earth and the other planets. The program's objective is to develop, within reasonable time frames, those

emerging and innovative technologies that will make possible both new and enhanced missions and system concepts. Author

A88-15848*# National Aeronautics and Space Administration, Washington, D.C.
THE IMPACT OF LAUNCH VEHICLE CONSTRAINTS ON U.S. SPACE STATION DESIGN AND OPERATIONS
JUDITH H. AMBRUS and DANIEL H. HERMAN (NASA, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 3 p.
(IAF PAPER 87-72)

The assembly of the Space Station is examined in terms of user and operational requirements. The Space Shuttle/Space Station interface is analyzed. The effect of the changing space transportation environment on the Space Station assembly requirements and the lift capabilities of the Shuttle are investigated. Consideration is given to crew replacement and the Shuttle launch rate; the use of the advanced solid rocket motor to increase the lifting capability of the Shuttle to 52,000 lbs; and the use of ELVs for launching modules of the Space Station. I.F.

A88-15854#
SELECTED ADVANCED TECHNOLOGY STUDIES FOR THE U.S. SPACE STATION
R. W. HAGER (Boeing Aerospace Co., Huntsville, AL) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 9 p.
(IAF PAPER 87-79)

Results of three of the most significant studies completed as part of Work Package 1 of the U.S. Space Station are reported. In particular, water reclamation techniques have been developed using multifiltration methods and reverse osmosis with both longitudinal hollow fibers and spiral wound sheet structures. In the course of another study, methods of on-orbit pressurized module repair have been tested using the Neutral Buoyancy Test Facility at the Marshall Space Flight Center (MSFC). The discussion also covers the development and fabrication of a full scale flight weight, flight quality prototype pressurized module. V.L.

A88-15934*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE AEROASSIST FLIGHT EXPERIMENT
G. D. WALBERG, P. M. SIEMERS, III, R. L. CALLOWAY (NASA, Langley Research Center, Hampton, VA), and J. J. JONES (Analytical Mechanics Associates, Inc., Hampton, VA) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 11 p. refs
(IAF PAPER 87-197)

The key design drivers for the Aeroassist Flight Experiment are discussed and a description is given of the flight test vehicle, its flight conditions, and instrumentation. The aeroassisted orbital transfer vehicle (AOTV) operates at higher velocities than the Space Shuttle and at higher altitudes than Apollo. Issues such as the effect of shock-layer nonequilibrium on the levels of radiative and convective heating and of viscous and real-gas effects on vehicle aerodynamic characteristics are mentioned. K.K.

A88-16071#
A CONCEPTUAL DESIGN FOR A SINGLE-STAGE-TO-ORBIT SPACE STATION SERVICE VEHICLE
JOHN R. OLDS (North Carolina State University, Raleigh) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 10 p. refs
(IAF PAPER 87-ST-07)

An account is given of the design features and design methodology used in response to requirements for an SSTO vehicle for the servicing of the NASA Space Station. The SSTO spacecraft conforms to a 165-kt minimum landing speed, the use of LOX/LH2 propellants, and payload sizes of 20,000 lbs to LEO and 40,000 lbs to earth. By comparison with the Space Shuttle (including external tank and solid rocket boosters), which weighs 4.5 million lbs and is 184 ft long, the SSTO craft would weigh 4.68 million lbs and be 252 ft in length; the comparable weight of the much larger craft would be due primarily to the use of advanced structural and component technologies. O.C.

A88-16295
DESIGN-TO-PERFORMANCE
J. R. MITCHELL, S. M. SELTZER, and H. E. WORLEY (Control Dynamics Co., Huntsville, AL) IN: Automatic control in space 1985. Oxford and New York, Pergamon Press, 1986, p. 153-166. refs

The 'design-to-performance' method of controller design for a satellite of the level of complexity represented by the NASA Space Station is used to arrive at both on-orbit plant characteristics and a digital system for the control of this plant. Attention is given to the core technologies enabling the implementation of this method, as well as to their development status; actual sensor data obtained as a result of simple on-orbit tests are invoked. The use of sampled-data theory requires a minimum of sensors and actuators. O.C.

A88-21566* National Aeronautics and Space Administration, Washington, D.C.
SCIENCE ON SPACE STATION
DAVID C. BLACK (NASA, Office of Space Station, Washington, DC) (Columbus II; Proceedings of the Second Workshop, Hanover, Federal Republic of Germany, June 9-11, 1986) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 7, no. 1-2, 1987, p. 133-135.

Plans for space science activities on the International Space Station are reviewed from a NASA perspective. The present Station reference configuration is based on a dual-keel core unit (one habitation module and three laboratory modules supplied by NASA, ESA, and Japan) and provides for five attached systems (with up to four payloads each to be exposed to space) and several free-flying platforms (both polar orbiters and coorbiters). Particular attention is given to the space science aspects of the primary Station objectives defined by NASA (servicing and repair, platforms, pressurized modules, and attached payloads). Also discussed are the work of the Task Force on Scientific Uses of Space Station, the need for operational flexibility, the value of a continuous manned presence for experimental science, and the skills needed from the Station crew. T.K.

A88-21569
PROSPECTS AND PROBLEMS IN MICROGRAVITY FLUID SCIENCE
LUIGI G. NAPOLITANO (ESA, Paris, France) (Columbus II; Proceedings of the Second Workshop, Hanover, Federal Republic of Germany, June 9-11, 1986) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 7, no. 1-2, 1987, p. 149-155.

The current availability of ground-based and space microgravity facilities for research in fluid science is surveyed, and the implications of the findings for Space Station planning are considered. Consideration is given to fluid-science facilities, flight opportunities, time between flights, time allotted per experiment, experiments per flight, fields investigated, parameters measured, postflight data collection procedures, and the quality of the microgravity environment. Statistical data based on the author's experience are presented in extensive tables and graphs, and it is concluded that, under current conditions, the time required to acquire 100 data points in a typical experiment is 5 months on the ground but over 12.5 years in space. Recommendations include expansion and extended availability of different kinds of space microgravity facilities, support for commercial microgravity R&D in space, and greater international information exchange and cooperation. T.K.

A88-21572
TOWARD NEW MATERIALS PROCESSING IN SPACE
SHIGERU MAEKAWA (Ministry of International Trade and Industry, Electrotechnical Laboratory, Sakura, Japan) (Columbus II; Proceedings of the Second Workshop, Hanover, Federal Republic

of Germany, June 9-11, 1986) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 7, no. 1-2, 1987, p. 165-170.

The future industrial utilization of space for material processing is considered from a Japanese perspective, with a focus on the organization and scheduling of R&D programs. The present status of preliminary studies in Japan is surveyed; the processes leading from basic research to industrial production in semiconductor technology are shown in extensive flow charts and briefly characterized; the important differences between ground-based and space experiments are indicated; and the potential role of the International Space Station is discussed. T.K.

A88-22063#
A CONCEPTUAL DESIGN FOR A SINGLE-STAGE-TO-ORBIT SPACE STATION SERVICE VEHICLE
JOHN R. OLDS (North Carolina State University, Raleigh) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. refs
(AIAA PAPER 88-0089)

A single-stage-to-orbit aerospace vehicle designed to service the Space Station is described. Design restrictions included a minimum landing speed, stability at low and high speeds, and the use of LOX/LH2 propellants. The preliminary vehicle configuration has a landing speed of 131 knots at 15-deg angle of attack, a gross lift-off weight of 4,680,000 lbs, and a length of 252 ft; the payload weight fraction is 0.004274. It is noted that further investigation is needed to evaluate reentry performance, structural integrity, and thermal protection. K.K.

A88-22253*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
ADVANCED PROTEIN CRYSTAL GROWTH FLIGHT HARDWARE FOR THE SPACE STATION
FREDERICK T. HERRMANN (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. refs
(AIAA PAPER 88-0345)

The operational environment of the Space Station will differ considerably from the previous short term missions such as the Spacelabs. Limited crew availability combined with the near continuous operation of Space Station facilities will require a high degree of facility automation. This paper will discuss current efforts to develop automated flight hardware for advanced protein crystal growth on the Space Station. Particular areas discussed will be the automated monitoring of key growth parameters for vapor diffusion growth and proposed mechanisms for control of these parameters. A history of protein crystal growth efforts will be presented in addition to the rationale and need for improved protein crystals for X-ray diffraction. The facility will be capable of simultaneously processing several hundred protein samples at various temperatures, pH's, concentrations etc., and provide allowances for real time variance of growth parameters. Author

A88-22484#
INDUSTRIAL SPACE FACILITY
OLAV SMISTAD (Space Industries, Inc., Houston, TX) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 7 p.
(AIAA PAPER 88-0649)

The design and capabilities of the proposed Industrial Space Facility (ISF), a permanently deployed, man-tended space platform, are described. The ISF is to be utilized for materials research and manufacturing in space, scientific research, and storage applications, and as a test platform and laboratory. Unique features of the facility include abundant power, cooling, and large pressurized volumes. The ISF is composed of a facility module (FM), an auxiliary module (AM), and a docking system. The facility module is to be 35 ft long, 14.5 ft in diameter, and to have 2500 cu ft of pressurized internal volume. The ISF is to operate in a circular 220 nautical mile orbit, and facility resupply is to be provided by exchanging a restocked AM for a depleted AM. The design of the facility is modular to allow for growth and it can be customized for user's needs. The initial deployment sequence, servicing mission, and mission profile are examined. Diagrams of the ISF and FM are provided. I.F.

A88-22549#
TRUE ENERGY ATMOSPHERIC SIMULATOR FOR LOW EARTH ORBIT SPECIES
G. C. PHAM-VAN-DIEP and E. P. MUNTZ (Southern California, University, Los Angeles) AIAA, Aerospace Science; Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 31 p. USAF-supported research. refs
(AIAA PAPER 88-0727)

Modern surface diagnostics and laser gas phase spectroscopic techniques allow detailed surface characteristics and gas-phase energy state populations to be obtained. Attention is presently given to the performance of devices that can furnish atmospheric species on a continuous basis in the 5-20 eV range with sufficient flux for the derivation of detailed, state-specific measurements. The intended application for those techniques is the detailed specification of the state of the gases used to simulate LEO conditions' species. O.C.

A88-26166
SPOT 1 - EARTH OBSERVING SATELLITE [SPOT 1 - SATELLITE D'OBSERVATION DE LA TERRE]
ROGER FERLET (CNRS, Institut d'Astrophysique, Paris, France) L'Astronomie (ISSN 0004-6302), vol. 101, Nov. 1987, p. 567-571. In French.

The on-board instrumentation and orbital parameters of the SPOT 1 earth observing satellite are discussed. Total earth coverage is achieved by SPOT in a circular sun-synchronous orbit at 822 km altitude with an orbital inclination of 98.7 deg. SPOT makes 14 + 5/26 revolutions per day, and completes its cycle of earth coverage each 26 days. The high-resolution (20-10 m) optical instruments on-board SPOT can produce 1/100,000 topographic maps. The ability to obtain views of a single region many times during the 26-day cycle allows the study of rapidly changing phenomena. The series of 6000 CCD detectors can simultaneously image a 60-km field at 10-m resolution. R.R.

A88-27750*# National Aeronautics and Space Administration, Washington, D.C.
IN-SPACE RESEARCH, TECHNOLOGY AND ENGINEERING EXPERIMENTS AND SPACE STATION
RICHARD TYSON (NASA, Office of Aeronautics and Space Technology, Washington, DC) and CHARLES F. GARTRELL (General Research Corp., McLean, VA) AIAA, Meeting on Space Station Utilization, 1st, Arlington, VA, Mar. 7-9, 1988, Paper. 18 p. refs

The NASA Space Station will serve as a technology research laboratory, a payload-servicing facility, and a large structure fabrication and assembly facility. Space structures research will encompass advanced structural concepts and their dynamics, advanced control concepts, sensors, and actuators. Experiments dealing with fluid management will gather data on such fundamentals as multiphase flow phenomena. As requirements for power systems and thermal management grow, experiments quantifying the performance of energy systems and thermal management concepts will be undertaken, together with expanded efforts in the fields of information systems, automation, and robotics. O.C.

A88-28257#
EFFECT OF ROTATING EARTH FOR ANALYSIS OF AEROASSISTED ORBITAL TRANSFER VEHICLES
HIDEO IKAWA (Aerojet Propulsion Research Institute, Sacramento, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, Jan.-Feb. 1988, p. 47-52. Previously cited in issue 23, p. 3422, Accession no. A86-47678. refs

A88-31385*# Analytical Mechanics Associates, Inc., Hampton, Va.
STEADY STATE MICRO-G ENVIRONMENT ON SPACE STATION
L. WATERS, M. HECK (Analytical Mechanics Associates, Inc., Hampton, VA), and L. DERYDER (NASA, Langley Research Center, Hampton, VA) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 64-71.
(AIAA PAPER 88-2462)

In circular earth orbit, the Space Station (SS) will sense acceleration from external environmental forces due to the gravitational gradient, rotational accelerations, and atmospheric drag. This paper discusses these forces and how they will affect the SS micro-g environment. The effect of SS attitude on the micro-g profile is addressed. Sources for nonsteady state acceleration levels for which disturbance models are currently being developed are briefly considered. C.D.

A88-32477
AEROTHERMODYNAMICS - A KEY TO NEW AEROSPACE TRANSPORT SYSTEMS [AEROTHERMODYNAMIK - EIN SCHLUESSEL ZU NEUEN TRANSPORTGERAETEN DER LUFT- UND RAUMFAHRT]
G. KOPPENWALLNER (DFVLR, Institut fuer Experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany) (DGLR, Jahrestagung 1987 - Blick in die Zukunft der Luft- und Raumfahrt - Projekte, Technologien und Nutzung, Technische Universitaet Berlin, Federal Republic of Germany, Oct. 5-7, 1987) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 12, Jan.-Feb. 1988, p. 6-18. In German. refs
(DGLR PAPER 87-077)

The aerothermodynamic (ATD) characteristics of proposed aerospace vehicles are examined in an analytical review and illustrated with extensive diagrams, graphs, and tables of numerical data. Vehicles considered are a Mach 5 transport aircraft, the winged airbreathing first stage and winged second stage of an STS, and orbital vehicles such as the ESA Man-Tended Free Flyer for the International Space Station. The relevant atmospheric properties at different altitudes are summarized; a brief ATD analysis of the interactions among gas, body, and flow is given, and typical hypersonic flow phenomena are described. It is argued that the wind-tunnel facilities presently available in the FRG are inadequate for realistic ATD simulations of advanced aerospace vehicles. T.K.

N88-10047*# McDonnell-Douglas Astronautics Co., Huntsville, Ala.
SPACE STATION MISSION PLANNING SYSTEM (MPS) DEVELOPMENT STUDY. VOLUME 1: EXECUTIVE SUMMARY Final Report
W. J. KLUS Mar. 1987 50 p
(Contract NAS8-37275)
(NASA-CR-179202; NAS 1.26:179202; MDC-W5108-VOL-1)
Avail: NTIS HC A03/MF A01 CSCL 22A

The basic objective of the Space Station (SS) Mission Planning System (MPS) Development Study was to define a baseline Space Station mission plan and the associated hardware and software requirements for the system. A detailed definition of the Spacelab (SL) payload mission planning process and SL Mission Integration Planning System (MIPS) software was derived. A baseline concept was developed for performing SS manned base payload mission planning, and it was consistent with current Space Station design/operations concepts and philosophies. The SS MPS software requirements were defined. Also, requirements for new software include candidate programs for the application of artificial intelligence techniques to capture and make more effective use of mission planning expertise. A SS MPS Software Development Plan was developed which phases efforts for the development software to implement the SS mission planning concept. B.G.

N88-10048*# McDonnell-Douglas Astronautics Co., Huntsville, Ala.
SPACE STATION MISSION PLANNING SYSTEM (MPS) DEVELOPMENT STUDY. VOLUME 2 Final Report
W. J. KLUS Mar. 1987 348 p
(Contract NAS8-37275)
(NASA-CR-179200; NAS 1.26:179200; MDC-W5108-VOL-2)
Avail: NTIS HC A15/MF A01 CSCL 22A

The process and existing software used for Spacelab payload mission planning were studied. A complete baseline definition of the Spacelab payload mission planning process was established, along with a definition of existing software capabilities for potential extrapolation to the Space Station. This information was used as a basis for defining system requirements to support Space Station mission planning. The Space Station mission planning concept was reviewed for the purpose of identifying areas where artificial intelligence concepts might offer substantially improved capability. Three specific artificial intelligence concepts were to be investigated for applicability: natural language interfaces; expert systems; and automatic programming. The advantages and disadvantages of interfacing an artificial intelligence language with existing FORTRAN programs or of converting totally to a new programming language were identified. B.G.

N88-10049*# McDonnell-Douglas Astronautics Co., Huntsville, Ala.
SPACE STATION MISSION PLANNING STUDY (MPS): DEVELOPMENT STUDY. VOLUME 3: SOFTWARE DEVELOPMENT PLAN Final Report
W. L. KLUS Mar. 1987 74 p
(Contract NAS8-37275)
(NASA-CR-179203; NAS 1.26:179203; MDC-W5108-VOL-3)
Avail: NTIS HC A04/MF A01 CSCL 22A

A software development plan is presented for the definition, design, and implementation of the Space Station (SS) Payload Mission Planning System (MPS). This plan is an evolving document and must be updated periodically as the SS design and operations concepts as well as the SS MPS concept evolve. The major segments of this plan are as follows: an overview of the SS MPS and a description of its required capabilities including the computer programs identified as configurable items with an explanation of the place and function of each within the system; an overview of the project plan and a detailed description of each development project activity breaking each into lower level tasks where applicable; identification of the resources required and recommendations for the manner in which they should be utilized including recommended schedules and estimated manpower requirements; and a description of the practices, standards, and techniques recommended for the SS MPS Software (SW) development. Author

N88-10071*# Martin Marietta Corp., Denver, Colo.
TELEPRESENCE WORK STATION SYSTEM DEFINITION STUDY, PART 2 Final Report
May 1987 65 p
(Contract NAS9-17230)
(NASA-CR-172006; NAS 1.26:172006; MCR-86-526) Avail: NTIS HC A04/MF A01 CSCL 22B

This study effort has shown that the development of a space robotic servicing system is totally feasible. More importantly, many of the key elements of such a system are currently available as the result of previous and ongoing technical efforts. In many cases, decisions remain to be made concerning tradeoffs between options available to satisfy system technology requirements. The primary recommendation resulting from this study is for the development of a flight test bed system that could be used to establish a performance database to assist some of the necessary technical decisions described in the study package. A properly design flight test bed system would prove tremendously useful in terms of rapidly evaluating technology in a realistic setting and would be a great benefit in the development of the operational system. Author

N88-10640*# National Aeronautics and Space Administration, Washington, D.C.
A TEST-BED FOR SPACE INTERFEROMETRY: SPACE PLATFORM INTERFEROMETER (SPI)
M. FAUCHERRE, L. DAME, P. V. STACHNIK, and W. A. TRAUB (Harvard-Smithsonian Center for Astrophysics, Cambridge, Mass.) *In* ESA, ESA Workshop on Optical Interferometry in Space p 197-204 Aug. 1987
Avail: NTIS HC A11/MF A01

The Space Platform Interferometer (SPI), a 20-m two-mirror Michelson interferometer, which can reach magnitude 14 at UV and visible wavelengths, is described. The SPI is attached to a platform serviced from the space station. In addition to its ability to produce unique science in the UV, SPI is intended to demonstrate the feasibility of larger projects in the field. Dynamical behavior of the structure in the gravity gradient environment and fringe stabilization at low photon rate are studied by picking up an adjacent bin (in the near IR) on the same object and using it to track the white light fringe in a separate differential interferometer. The same subsystem also corrects for tilt. Active control of critical parameters ensures optical rigidity. Performances are evaluated in low orbit.
ESA

N88-10829*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
FOURTEENTH SPACE SIMULATION CONFERENCE: TESTING FOR A PERMANENT PRESENCE IN SPACE
JOSEPH L. STECHER, III, ed. 1986 435 p Conference held in Baltimore, Md., 3-6 Nov. 1986; sponsored by NASA, Inst. of Environmental Sciences, AIAA, and the American Society for Testing and Materials
(NASA-CP-2446; REPT-86B0561; NAS 1.55:2446) Avail: NTIS HC A19/MF A01 CSCL 22B

The Institute of Environmental Sciences Fourteenth Space Simulation Conference, Testing for a Permanent Presence in Space, provided participants a forum to acquire and exchange information on the state-of-the-art in space simulation, test technology, thermal simulation, and protection, contamination, and techniques of test measurements.

N88-10878*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
RESEARCH AND DEVELOPMENT AT THE MARSHALL SPACE FLIGHT CENTER NEUTRAL BUOYANCY SIMULATOR
VYGANTAS P. KULPA *In* NASA. Langley Research Center, Hampton, Va. Space Construction p 142-152 Oct. 1987
Avail: NTIS HC A14/MF A01 CSCL 14B

The Neutral Buoyancy Simulator (NBS), a facility designed to imitate zero-gravity conditions, was used to test the Experimental Assembly of Structures in Extravehicular Activity (EASE) and the Assembly Concept for Construction of Erectable Space Structures (ACCESS). Neutral Buoyancy Simulator applications and operations; early space structure research; development of the EASE/ACCESS experiments; and improvement of NBS simulation are summarized.
B.G.

N88-12532*# Science Applications International Corp., Huntsville, Ala.
OPTIMIZATION TECHNIQUES APPLIED TO PASSIVE MEASURES FOR IN-ORBIT SPACECRAFT SURVIVABILITY Final Report
ROBERT A. MOG and D. MARVIN PRICE Nov. 1987 299 p (Contract NAS8-37378)
(NASA-CR-179216; NAS 1.26:179216; HV410-12) Avail: NTIS HC A13/MF A01 CSCL 22B

Optimization techniques applied to passive measures for in-orbit spacecraft survivability, is a six-month study, designed to evaluate the effectiveness of the geometric programming (GP) optimization technique in determining the optimal design of a meteoroid and space debris protection system for the Space Station Core Module configuration. Geometric Programming was found to be superior to other methods in that it provided maximum protection from impact problems at the lowest weight and cost.
Author

N88-13382* National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION SYSTEMS: A BIBLIOGRAPHY WITH INDEXES
Nov. 1987 245 p
(NASA-SP-7056(05); NAS 1.21:7056(05)) Avail: NTIS HC A11 CSCL 22B

This bibliography lists 967 reports, articles, and other documents introduced into the NASA scientific and technical information system between January 1, 1987 and June 30, 1987. Its purpose is to provide helpful information to the researcher, manager, and designer in technology development and mission design according to system, interactive analysis and design, structural and thermal analysis and design, structural concepts and control systems, electronics, advanced materials, assembly concepts, propulsion, and solar power satellite systems. The coverage includes documents that define major systems and subsystems, servicing and support requirements, procedures and operations, and missions for the current and future space station.
Author

N88-14873*# Washington Univ., Seattle. Dept. of Mechanical Engineering.
INVENTORY BEHAVIOR AT REMOTE SITES Final Report
WILLIAM C. LEWIS, JR. *In* NASA. Lyndon B. Johnson Space Center, Houston, Tex. NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 1 24 p Nov. 1987
Avail: NTIS HC A15/MF A01 CSCL 12B

An operations research study was conducted concerning inventory behavior on the space station. Historical data from the Space Shuttle was used. The results demonstrated a high logistics burden if Space Shuttle reliability technology were to be applied without modification to space station design (which it was not). Effects of rapid resupply and on board repair capabilities on inventory behavior were investigated.
Author

N88-15356*# Arizona State Univ., Tempe.
PLANETARY SCIENCE
JOHN R. MARSHALL, FRANK BRIDGES, DONALD GAULT, RONALD GREELEY, HARRY HOUPIS, DOUGLAS LIN, and STUART WEIDENSCHILLING (Planetary Science Inst., Tucson, Ariz.) *In* NASA. Ames Research Center, Moffett Field, Calif. Microgravity Particle Research on the Space Station p 11-18 Dec. 1987
Avail: NTIS HC A03/MF A01 CSCL 03B

The following types of experiments for a proposed Space Station Microgravity Particle Research Facility are described: (1) low velocity collisions between fragile particles; (2) low velocity collisions of ice particles; (3) plasma-dust interaction; and (4) aggregation of finely-comminuted geological materials. The required capabilities and desired hardware for the facility are detailed.
J.P.B.

N88-15357*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ATMOSPHERIC SCIENCE
PATRICK HAMILL, THOMAS ACKERMAN, ANTONY CLARKE, JINDRA GOODMAN, ZEV LEVIN, MARTIN TOMASKO (Arizona Univ., Tucson), O. BRIAN TOON, and ROBERT WHITTEN *In its* Microgravity Particle Research on the Space Station p 19-24 Dec. 1987
Avail: NTIS HC A03/MF A01 CSCL 04A

The following types of experiments for a proposed Space Station Microgravity Particle Research Facility are described: (1) growth of liquid water drop populations; (2) coalescence; (3) drop breakup; (4) breakup of freezing drops; (5) ice nucleation for large aerosols or bacteria; (6) scavenging of gases, for example, SO2 oxidation; (7) phoretic forces, i.e., thermophoresis versus diffusiophoresis; (8) Rayleigh bursting of drops; (9) charge separation due to collisions of rimed and unrimed ice; (10) charged drop dynamics; (11) growth of particles in other planetary atmospheres; and (12) freezing and liquid-liquid evaporation. The required capabilities and desired hardware for the facility are detailed.
J.P.B.

N88-19477*# Lockheed Missiles and Space Co., Huntsville, Ala. Engineering Center.
PRELIMINARY ANALYSIS OF AN INTEGRATED LOGISTICS SYSTEM FOR OSSA PAYLOADS Final Contractor Report, 15 Sep. 1986 - 15 Apr. 1987
T. PALGUTA, W. BRADLEY, and T. STOCKTON Feb. 1988 104 p
(Contract NAS8-32697)
(NASA-CR-4114; NAS 1.26:4114; LMSC-HEC-TR-D068015)
Avail: NTIS HC A06/MF A01 CSCL 22A

The results of studies of the Office of Space Science and Applications' (OSSA) need for an integrated logistics system to support OSSA payloads, whether attached to the Space Station or free-flying are detailed. An executive summary, the integrated logistics support strategy, preparation of planning documents and a supportability analysis of the 1.8 meter centrifuge are discussed.

N88-19478*# Lockheed Missiles and Space Co., Huntsville, Ala. Engineering Center.
PRELIMINARY ANALYSIS OF AN INTEGRATED LOGISTICS SYSTEM FOR OSSA PAYLOADS. VOLUME 1: EXECUTIVE SUMMARY
T. PALGUTA, W. BRADLEY, and T. STOCKTON *In its* Preliminary Analysis of an Integrated Logistics System for OSSA Payloads p 1-23 Feb. 1988
Avail: NTIS HC A06/MF A01 CSCL 22A

The purpose is to describe the logistics study background and approach to providing estimates of of logistics support requirements for Office of Space Science and Applications' payloads in the Space Station era. A concise summary is given of the study results. Future logistics support analysis tasks are identified. Author

N88-19479*# Lockheed Missiles and Space Co., Huntsville, Ala. Engineering Center.
PRELIMINARY ANALYSIS OF AN INTEGRATED LOGISTICS SYSTEM FOR OSSA PAYLOADS. VOLUME 2: OSSA INTEGRATED LOGISTICS SUPPORT STRATEGY
T. PALGUTA, W. BRADLEY, and T. STOCKTON *In its* Preliminary Analysis of an Integrated Logistics System for OSSA Payloads p 25-61 Feb. 1988
Avail: NTIS HC A06/MF A01 CSCL 22A

The purpose is to outline an Office of Space Science and Applications (OSSA) integrated logistics support strategy that will ensure effective logistics support of OSSA payloads at an affordable life-cycle cost. Program objectives, organizational relationships, and implementation of the logistics strategy are discussed. Author

N88-19480*# Lockheed Missiles and Space Co., Huntsville, Ala. Engineering Center.
PRELIMINARY ANALYSIS OF AN INTEGRATED LOGISTICS SYSTEM FOR OSSA PAYLOADS. VOLUME 3: OSSA INTEGRATED LOGISTICS SUPPORT PLANNING DOCUMENT
T. PALGUTA, W. BRADLEY, and T. STOCKTON *In its* Preliminary Analysis of an Integrated Logistics System for OSSA Payloads p 63-83 Feb. 1988
Avail: NTIS HC A06/MF A01 CSCL 22A

Guidance in preparing and updating an integrated logistics support plan (ILSP) is given. Clear, concise, and detailed instructions are provided on the preparation and content of an ILSP in order to ensure a quality document that reflects total program requirements. Author

N88-19481*# Lockheed Missiles and Space Co., Huntsville, Ala. Engineering Center.
PRELIMINARY ANALYSIS OF AN INTEGRATED LOGISTICS SYSTEM FOR OSSA PAYLOADS. VOLUME 4: SUPPORTABILITY ANALYSIS OF THE 1.8M CENTRIFUGE
T. PALGUTA, W. BRADLEY, and T. STOCKTON *In its* Preliminary Analysis of an Integrated Logistics System for OSSA Payloads p 85-100 Feb. 1988
Avail: NTIS HC A06/MF A01 CSCL 22A

Supportability issues for the 1.8 meter centrifuge in the Life Science Research Facility are addressed. The analysis focuses on reliability and maintainability and the potential impact on supportability and affordability. Standard logistics engineering methodologies that will be applied to all Office of Space Science and Applications' (OSSA) payload programs are outlined. These methodologies are applied to the 1.8 meter centrifuge. Author

N88-19487# Erno Raumfahrttechnik G.m.b.H., Bremen (West Germany).
MISSION PROFILES OF THE MTFF CO-ORBITING WITH THE US SPACE STATION
W. WOLFSBERGER *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 13-18 Nov. 1987
Avail: NTIS HC A21/MF A01

Guidelines for fuel-efficient mission profile design of the Man-Tended Free Flyer (MTFF) are presented. It is assumed the MTFF is co-orbiting with the U.S. Space Station (USSS). After a 6 month coasting phase (micro-g environment) the MTFF has to return to the USSS for servicing. The relative motion of the MTFF with respect to the USSS is characterized as boomerang-motion. Collision avoidance, entry risk at low altitude boomerangs, and abort of the boomerang are discussed. ESA

N88-19501*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
MULTIMISSION MODULAR SPACECRAFT (MMS), A SERVICEABLE DESIGN SPACECRAFT
EDWARD FALKENHAYN *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 141-144 Nov. 1987
Avail: NTIS HC A21/MF A01 CSCL 22B

A standard spacecraft bus compatible with NASA launch vehicles, including STS, for four reference missions (Sun, Earth, stellar pointing from low Earth orbit, Earth pointing from geostationary orbit) was designed. The modular serviceable design stems from its use of passive acme screws for module attachment and scoop proof electrical connectors for electrical interfaces. A flight support system includes command and telemetry links. ESA

N88-19686*# Southern California Inst. of Architecture, Santa Monica. Inst. for Future Studies.
SPACE STATION GROUP ACTIVITIES HABITABILITY MODULE STUDY: A SYNOPSIS
DAVID NIXON and TERRY GLASSMAN *In* NASA. Ames Research Center, Space Station Human Factors Research Review. Volume 3: Space Station Habitability and Function: Architectural Research p 145-153 Oct. 1987
Avail: NTIS HC A10/MF A01 CSCL 05H

Space station habitability was studied by investigating crew activity routines, proximities, ergonomic envelopes, and group volumes. Ten alternative schematic interior designs were proposed. Preliminary conclusions include: (1) in-service interior modifications may be necessary and should be planned for; (2) design complexity will be increased if the module cluster is reduced from five to three; (3) the increased crew circulation attendant upon enhancement of space station activity may produce human traffic bottlenecks and should be planned for; (4) a single- or two-person quiet area may be desirable to provide crew members with needed solitude during waking hours; and (5) the decision to choose a two-shift or three-shift daily cycle will have a significant impact on the design configuration and operational efficiency of the human habitat. J.P.B.

02

MODELS, ANALYTICAL DESIGN TECHNIQUES, AND ENVIRONMENTAL DATA

Includes descriptions of computerized interactive systems design and development techniques, computer codes, internal and external environmental models and data.

A88-20486* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AUTOPLAN - A PC-BASED AUTOMATED MISSION PLANNING TOOL
FRANK C. PATERRA, MARC S. ALLEN (Computer Technology Associates, Inc., Newport News, VA), and GEORGE F. LAWRENCE (NASA, Langley Research Center, Hampton, VA) Telematics and Informatics (ISSN 0736-5853), vol. 4, no. 4, 1987, p. 263-273.
(Contract NAS1-18247)

A PC-based automated mission and resource planning tool, AUTOPLAN, is described, with application to small-scale planning and scheduling systems in the Space Station program. The input is a proposed mission profile, including mission duration, number of allowable slip periods, and requirement profiles for one or more resources as a function of time. A corresponding availability profile is also entered for each resource over the whole time interval under study. AUTOPLAN determines all integrated schedules which do not require more than the available resources. R.R.

A88-21079
FACILE - A COMPUTER PROGRAM FOR SPACE STATION FACILITIES LAYOUT AND ACTIVITY SIMULATION
THOMAS S. TULLIS (McDonnell Douglas Astronautics Co., Huntington Beach, CA) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 5 p.
(SAE PAPER 871415)

FACILE is a computer program that aids in the design of interior layouts for complex facilities like the Space Station. The program supports three kinds of functions: design, evaluation, and simulation. The design features of FACILE include a direct-manipulation style of user interface for defining and manipulating the functional compartments of the facility. The evaluation features include the capability of quantitatively comparing any candidate layout against five crew-interface criteria: crew movement, sequential dependencies, shared support equipment, noise interference, and privacy requirements. The simulation features include the capability of simulating the activities of any number of crew members within the candidate layout. Statistics such as crew movement distances, compartment usage rates, and queuing times waiting for compartments are available from the simulations. Author

A88-21089* Hamilton Standard, Windsor Locks, Conn.
SIMULATION AND CONTROL OF A SPACE STATION AIR REVITALIZATION SYSTEM
JAMES L. YANOSY (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) and LAWRENCE F. ROWELL (NASA, Langley Research Center, Hampton, VA) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 12 p. refs
(SAE PAPER 871425)

A computer simulation tool is written to investigate simulation and control of a Space Station air revitalization system. Candidate subsystems for various air revitalization roles in the Space Station have been and continue to be tested. However, integration and control of these subsystems into an effective system which revitalizes the air in all habitable areas needs to be evaluated. From such an evaluation, the size of subsystems, size and location of accumulators, and decisions on bussing of carbon dioxide, hydrogen, oxygen, and nitrogen can be affected. In addition, various control approaches can be assessed. The computer simulation model is described and its applications are presented. Author

A88-21642* Mitre Corp., Houston, Tex.
AN APPROACH TO DESIGN KNOWLEDGE CAPTURE FOR THE SPACE STATION
D. B. WECHSLER (Mitre Corp., Houston, TX) and K. R. CROUSE (NASA, Johnson Space Center, Houston, TX) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 106-113. Previously announced in STAR as N87-12597. refs

The design of NASA's space station has begun. During the design cycle, and after activation of the space station, the reoccurring need will exist to access not only designs, but also deeper knowledge about the designs, which is only hinted in the design definition. Areas benefiting from this knowledge include training, fault management, and onboard automation. NASA's Artificial Intelligence Office at Johnson Space Center and The MITRE Corporation have conceptualized an approach for capture and storage of design knowledge. Author

A88-21643* Michigan Univ., Ann Arbor.
TRANSLATION AND EXECUTION OF DISTRIBUTED ADA PROGRAMS - IS IT STILL ADA?
RICHARD A. VOLZ, TREVOR N. MUDGE, GREGORY D. BUZZARD, and PADMANABHAN KRISHNAN (Michigan, University, Ann Arbor) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 114-125. Research supported by the General Dynamics Corp. refs
(Contract NAG2-350)

Some of the fundamental issues and tradeoffs for distributed execution systems for the Ada language are examined. Steps that need to be taken to deal with heterogeneity of addressing program objects, of processing resources, and of the individual processor environment are considered. The ways in which program elements can be assigned are examined in the context of four issues: implied remote object access, object visibility and recursive execution, task termination problems, and distributed types. C.D.

A88-21644* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLAN-IT - KNOWLEDGE-BASED MISSION SEQUENCING
ERIC W. BIEFELD (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 126-130. refs

PLAN-IT (Plan-Integrated Timelines), a knowledge-based approach to assist in mission sequencing, is discussed. PLAN-IT uses a large set of scheduling techniques known as strategies to develop and maintain a mission sequence. The approach implemented by PLAN-IT and the current applications of PLAN-IT for sequencing at NASA are reported. C.D.

A88-22413#
LOWERING THE COSTS OF SATELLITE OPERATIONS - LESSONS LEARNED FROM THE SOLAR MESOSPHERE EXPLORER (SME) MISSION
E. HANSEN (Colorado, University, Boulder) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 17 p. refs
(AIAA PAPER 88-0549)

The lessons learned from the Solar Mesosphere Explorer have been the key to the development of a low-cost model for spacecraft operations. Principles of project management, integrated design, lifecyle continuity, and human factors management have been developed that will help guide the development of the next generation of space missions. This model has been applied to several NASA projects, including Space Station studies and the Mars Observer mission. Using this approach has lowered costs and has given scientists the capability of interactively controlling

their instruments from their home laboratories. In follow-on studies, generic operations system tools have been developed as part of an Operations and Science Instrument Support (OASIS) package. Author

A88-22512*# National Aeronautics and Space Administration, Washington, D.C.
OUTER ATMOSPHERIC RESEARCH
JOHN L. ANDERSON (NASA, Large Space Systems Technology, Washington, DC) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(AIAA PAPER 88-0686)

The region above the earth from about 90 km to 150 km is a major part of the upper or outer atmosphere. It is relatively unexplored, being too high for balloons or aircraft and too low for persistent orbiting spacecraft. However, the concept of a tethered subsatellite, deployed downward from an orbiting, more massive craft such as the Space Shuttle, opens the possibility of a research capability that could provide global mapping of this region. The need for research in this thick spherical shell above the earth falls into two major categories: (1) scientific data for understanding and modeling the global atmosphere and thereby determining its role in the earth system, and (2) engineering data for the design of future aerospace vehicles that will operate there. This paper presents an overview and synthesis of the currently perceived research needs and the state-of-the-art of the proposed tethered research capability. Author

A88-26209
APPLYING TECHNOLOGY TO SYSTEMS; AEROSPACE COMPUTER SECURITY CONFERENCE, 3RD, ORLANDO, FL, DEC. 7-11, 1987, TECHNICAL PAPERS
Conference sponsored by AIAA, American Society for Industrial Security, and IEEE. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, 170 p. For individual items see A88-26210 to A88-26213.

The present conference discusses the Secure Distributed Operating System project for the verification of hookup security, active vs. passive security models, an expert system for the classification and sanitizing of texts, developments in guidance for trusted computer networks, the interconnection of accredited systems, and engineering systems applicable to embedded multilevel secure operations. Also discussed are network covert channel analysis, NASA Space Station program threat and vulnerability analysis, criterion extension for distributed systems, a transport encapsulation security protocol, and the protection of sensitive systems and data in an open governmental agency. O.C.

A88-32190*# California Univ., Santa Barbara.
AN EFFICIENT MULTILEVEL OPTIMIZATION METHOD FOR ENGINEERING DESIGN
G. N. VANDERPLAATS, Y. J. YANG, and D. S. KIM (California, University, Santa Barbara) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 125-132. refs
(Contract NAG1-567)
(AIAA PAPER 88-2226)

An efficient multilevel design optimization technique is presented. The proposed method is based on the concept of providing linearized information between the system level and subsystem level optimization tasks. The advantages of the method are that it does not require optimum sensitivities, nonlinear equality constraints are not needed, and the method is relatively easy to use. The disadvantage is that the coupling between subsystems is not dealt with in a precise mathematical manner. Author

A88-32284#
OPTIMAL ON-LINE MEASUREMENT SYSTEM CONFIGURATION STRATEGIES
YAAKOV OSHMAN and DANIEL J. INMAN (New York, State University, Buffalo) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1048-1058. refs
(AIAA PAPER 88-2341)

This paper introduces a new measurement system optimization technique which can be implemented on-line in time-varying, continous-time systems. A case in which several measurement subsystems are available, each one of which may serve to drive a state estimation algorithm, is considered. However, due to practical implementation constraints, only one of these subsystems can actually be used at a time. An algorithm is needed, by which the optimal measurement subsystem to be used at a certain time interval is selected at each measurement configuration epoch. The approach taken to solve this problem is based on using the square root continuous-time V-lambda filter as the underlying state estimation algorithm. This algorithm continously provides its user with the special factors of the estimation error covariance matrix, which are, in turn, used in this work as the basis for an on-line decision procedure by which the optimal measurement strategy is derived. A numerical example is presented, which demonstrates the performance of the new algorithm. Author

A88-32355#
THE COMPONENT-MODE METHOD IN A PARALLEL COMPUTER ENVIRONMENT
DUC T. NGUYEN, JAE-SOO SHIM (Old Dominion University, Norfolk, VA), and YONGXING ZHANG IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1705-1710. refs
(AIAA PAPER 88-2438)

In this paper, a version of the component-mode technique is reexamined and a 'global-local' parallel procedure for eigenvalue analysis is presented. Parallel computation at the global level is achieved by using the component-mode method. At the local level, parallel computation is achieved by coupling the subspace iteration technique with a parallel version of the generalized Jacobi iteration technique. Numerical examples are provided to validate the proposed procedure. Author

N88-10981# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).
THERMOPHYSICAL PROPERTIES MEASUREMENT FACILITY (TPMF) Final Report
Paris, France ESA Apr. 1987 25 p
(Contract ESA-6615/85-F-HEW(SC))
(ESA-CR(P)-2417; ETN-87-90879) Avail: NTIS HC A03/MF A01

A microgravity diffusion laboratory for the pressurized module or Man-Tended-Free-Flyer of the Columbus space station is proposed. The scientific background and experimental equipment needed in research on thermophysical properties were established. Stimuli and diagnostic units were defined. A design concept with a standard experimental chamber in triple arrangement and peripheral equipment as diagnostic instruments is elaborated. Feasibility aspects as well as required services, accommodation, and operation are covered. ESA

N88-14999*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A SPACE TRANSPORTATION SYSTEM OPERATIONS MODEL
W. DOUGLAS MORRIS and NANCY H. WHITE Dec. 1987 65 65 p
(NASA-TM-100481; NAS 1.15:100481) Avail: NTIS HC A04/MF A01 CSCL 22B

Presented is a description of a computer program which permits assessment of the operational support requirements of space transportation systems functioning in both a ground- and space-based environment. The scenario depicted provides for the delivery of payloads from Earth to a space station and beyond using upper stages based at the station. Model results are scenario dependent and rely on the input definitions of delivery requirements, task times, and available resources. Output is in terms of flight

rate capabilities, resource requirements, and facility utilization. A general program description, program listing, input requirements, and sample output are included. Author

N88-15618*# Oakwood Coll., Huntsville, Ala. Dept. of Business and Information Systems Management.
THE FEASIBILITY OF USING TAE AS THE UIL FOR THE SPACE STATION AND FOR OTHER INTERNAL NASA TASKS AND PROJECTS
ESTHER NAOMI GILL *In* NASA. Marshall Space Flight Center, Research Reports: 1987 NASA/ASEE Summer Faculty Fellowship Program 22 p Nov. 1987
Avail: NTIS HC A99/MF E03 CSCL 09B

This description of the Transportable Applications Executive (TAE) is intended to serve to test the feasibility of its use as the Space Station User Interface Language (SSUIL). TAE was developed by the Space Data and Computing Division, Space and Earth Sciences Directorate of NASA/GSFC, and by Century Computing, Inc. in 1980. TAE is an executive program which ties a system of application programs into a single easily operated whole and supports users' operations of programs through a consistent friendly and flexible interactive user interface. TAE also supplies the interface between the user and the various application programs in a particular computer system. It appears to be an effective user interface for infrequent as well as for expert users. Author

N88-15622*# New Mexico State Univ., University Park. Dept. of Mathematical Sciences.
CAN SPACE STATION SOFTWARE BE SPECIFIED THROUGH ADA?
ARTHUR KNOEBEL *In* NASA. Marshall Space Flight Center, Research Reports: 1987 NASA/ASEE Summer Faculty Fellowship Program 22 p Nov. 1987
Avail: NTIS HC A99/MF E03 CSCL 09B

Programming of the space station is to be done in the Ada programming language. A breadboard of selected parts of the work package for Marshall Space Flight Center is to be built, and programming this small part will be a good testing ground for Ada. One coding of the upper levels of the design brings out several problems with top-down design when it is to be carried out strictly within the language. Ada is evaluated on the basis of this experience, and the points raised are compared with other experience as related in the literature. Rapid prototyping is another approach to the initial programming; several different types of prototypes are discussed, and compared with the art of specification. Some solutions are proposed and a number of recommendations presented. Author

N88-16372*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
MTK: AN AI TOOL FOR MODEL-BASED REASONING Abstract Only
WILLIAM K. ERICKSON and MARY R. SCHWARTZ *In* NASA. Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 1 p 79 Nov. 1987
Avail: NTIS HC A18/MF A01 CSCL 09B

A 1988 goal for the Systems Autonomy Demonstration Project Office of the NASA Ames Research Center is to apply model-based representation and reasoning techniques in a knowledge-based system that will provide monitoring, fault diagnosis, control and trend analysis of the space station Thermal Management System (TMS). A number of issues raised during the development of the first prototype system inspired the design and construction of a model-based reasoning tool called MTK, which was used in the building of the second prototype. These issues are outlined, along with examples from the thermal system to highlight the motivating factors behind them. An overview of the capabilities of MTK is given. Author

N88-16375*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
KBS V AND V AS RELATED TO AUTOMATION OF SPACE STATION SUBSYSTEMS: RATIONALE FOR A KBS LIFECYCLE Abstract Only
K. RICHARDSON and C. WONG *In* NASA. Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 1 p 85 Nov. 1987
Avail: NTIS HC A18/MF A01 CSCL 09B

The role of verification and validation (V and V) in software has been to support and strengthen the software lifecycle and to ensure that the resultant code meets the standards of the requirements document. Knowledge based systems (KBS) V and V should serve the same role, but the KBS lifecycle is ill-defined. Here, the rationale on the simple form of the KBS lifecycle is explained. Special KBS development requirements are accommodated where possible by modifications to the traditional software lifecycle. Research areas are suggested for those aspects which present new or unusual difficulties for V and V. Author

N88-16417*# Auburn Univ., Ala. Dept. of Computer Science and Engineering.
PLANNING ACTIVITIES IN SPACE
KAI-HSIUNG CHANG *In* NASA. Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 1 p 315-319 Nov. 1987
Avail: NTIS HC A18/MF A01 CSCL 09B

Three aspects of planning activities in space are presented. These include generating plans efficiently, coordinating actions among multiple agents, and recovering from plan execution errors. Each aspect is discussed separately. Author

N88-16428*# General Research Corp., Huntsville, Ala.
PROTOTYPE RESUPPLY SCHEDULER
STEVE TANNER, ANGI HUGHES, and JIM BYRD (United Space Boosters, Inc., Huntsville, Ala.) *In* NASA. Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 1 p 383-387 Nov. 1987
Avail: NTIS HC A18/MF A01 CSCL 09B

Resupply scheduling for the Space Station presents some formidable logistics problems. One of the most basic problems is assigning supplies to a series of shuttle resupply missions. A prototype logistics expert system which constructs resupply schedules was developed. This prototype is able to reconstruct feasible resupply plans. In addition, analysts can use the system to evaluate the impact of adding, deleting or modifying launches, cargo space, experiments, etc. Author

N88-16809# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).
MODEL OF SPACE PLATFORM ELECTROMAGNETIC (EMC) CONFIGURATION Final Report
Paris, France ESA 30 Jun. 1987 114 p
(Contract ESA-6536/85-NL-MA(SC))
(ESA-CR(P)-2500; ETN-88-91705) Avail: NTIS HC A06/MF A01

The ESAESA tool containing an electromagnetic compatibility (EMC) data base, EMC prediction programs, EMC management data, and descriptive data (e.g., test set-ups) was developed, based on the Test Data Analysis System (TDAS), for EMC analysis of Columbus. The goals of ESAESA include improved project economics, harmonization, complete coverage of EMC work, improvement of tests and prediction data quality, and the ability to handle problems related to in-orbit assembly. ESA

N88-17239*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
DESIGN KNOWLEDGE CAPTURE FOR THE SPACE STATION
K. R. CROUSE and D. B. WECHSLER (Mitre Corp., Houston, Tex.) *In its* First Annual Workshop on Space Operations Automation and Robotics (SOAR 87) p 239-245 Oct. 1987
Avail: NTIS HC A23/MF A01 CSCL 22B

The benefits of design knowledge availability are identifiable and pervasive. The implementation of design knowledge capture

and storage using current technology increases the probability for success, while providing for a degree of access compatibility with future applications. The space station design definition should be expanded to include design knowledge. Design knowledge should be captured. A critical timing relationship exists between the space station development program, and the implementation of this project. Author

N88-19648*# Alabama Univ., Huntsville. Center for Microgravity and Materials Research.
ANALYSIS OF LOW GRAVITY TOLERANCE OF MODEL EXPERIMENTS FOR SPACE STATION: PRELIMINARY RESULTS FOR DIRECTIONAL SOLIDIFICATION Semiannual Report, 1 Oct. 1987 - 1 Apr. 1988
J. IWAN D. ALEXANDER and JALIL OUAZZANI 1988 47 p
(Contract NAG8-684)
(NASA-CR-182657; NAS 1.26:182657; SAR-1) Avail: NTIS HC A03/MF A01 CSCL 12A

It has become clear from measurements of the acceleration environment in the Spacelab that the residual gravity levels on board a spacecraft in low Earth orbit can be significant and should be of concern to experimenters who wish to take advantage of the low gravity conditions on future Spacelab missions and on board the Space Station. The basic goals are to better understand the low gravity tolerance of three classes of materials science experiments: crystal growth from a melt, a vapor, and a solution. The results of the research will provide guidance toward the determination of the sensitivity of the low gravity environment, the design of the laboratory facilites, and the timelining of materials science experiments. To data, analyses of the effects of microgravity environment were, with a few exceptions, restricted to order of magnitude estimates. Preliminary results obtained from numerical models of the effects of residual steady and time dependent acceleration are reported on: heat, mass, and momentum transport during the growth of a dilute alloy by the Bridgman-Stockbarger technique, and the response of a simple fluid physics experiment involving buoyant convection in a square cavity. B.G.

N88-19885*# Kalil (Michael) Design Studio, New York, N.Y.
SPACE STATION ARCHITECTURAL ELEMENTS MODEL STUDY
MICHAEL KALIL *In* NASA. Ames Research Center, Space Station Human Factors Research Review. Volume 3: Space Station Habitability and Function: Architectural Research p 137-143 Oct. 1987
(Contract NASA ORDER A-21776)
(REPT-31799) Avail: NTIS HC A10/MF A01 CSCL 05H

The space station must unite the properties and behavior of individual and place, using proportions from both to make whole the understanding of ourselves at this moment in evolution. Harmonious proportions in any environment are similar to the acceptance and enjoyment of the harmony of many well-tuned musical instruments. A well-tuned or well-ordered environment tends to have invisible proportions. They produce order but do not intrude on the perception and cognitive mapping of the environment. Systems of proportion are not ends in themselves but are a means to select a series of spaces which relate one to another in dimensionally specific terms. These internal relationships create a whole when the forms are harmonious. This harmonic relationship is of intrinsic value for individuals to be physically and psychologically in balance with their universe. Author

N88-19887*# Michigan Univ., Ann Arbor. Architecture and Planning Research Lab.
FULL SCALE ARCHITECTURAL SIMULATION TECHNIQUES FOR SPACE STATIONS
COLIN W. CLIPSON *In* NASA. Ames Research Center, Space Station Human Factors Research Review. Volume 3: Space Station Habitability and Function: Architectural Research p 155-164 Oct. 1987
Avail: NTIS HC A10/MF A01 CSCL 09B

A gaming simulation using the technique of empathic modeling was used to assess the behavior of participants in the routine and emergency operation of a mock-up space station infirmary. J.P.B.

03

STRUCTURAL CONCEPTS

Includes analyses and descriptions of different Space Station structural concepts, arrangements, testing, methods of construction and/or manufacturing and specific rotary joints, structural nodes, and columns.

A88-12591* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THERMAL RESPONSE OF INTEGRAL MULTICOMPONENT COMPOSITES TO A HIGH-ENERGY AEROTHERMODYNAMIC HEATING ENVIRONMENT WITH SURFACE TEMPERATURE TO 1800 K
DAVID A. STEWART and DANIEL B. LEISER (NASA, Ames Research Center, Moffett Field, CA) Ceramic Engineering and Science Proceedings (ISSN 0196-6219), vol. 8, July-Aug. 1987, p. 613-625. refs

Laminated composite insulations developed for potential use on advanced spacecraft operating between GEO and LEO were tested in an aerothermodynamic environment simulating an AOTV aerobraking maneuver (altitude 82.3 km and velocity = 9.0 km/s). Comparisons are discussed between these data and predictions of in-depth temperature response using dynamical thermal conductivity values to 2000 K. Author

A88-12719
DESIGN, ANALYSIS, FABRICATION AND TEST OF THE LAMAR PROTOFLIGHT MIRROR ASSEMBLY
LESTER M. COHEN, DANIEL G. FABRICANT, and PAUL GORENSTEIN (Harvard-Smithsonian Center for Astrophysics, Cambridge, MA) IN: X-ray imaging II; Proceedings of the Meeting, San Diego, CA, Aug. 21, 22, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 126-137.

An X-ray telescope for the LAMAR instrument has been designed, built and tested at the Smithsonian Astrophysical Observatory. In addition, telescope performance has been verified at the NASA Marshall Space Flight Center's long X-ray beam facility. After X-ray testing and data reduction is complete, the telescope will undergo vibration testing. Postvibration visible light tests will then verify no change in performance. The design and fabrication of this high-throughput Kirkpatrick-Baez geometry telescope incorporates the use of advanced composite materials (aluminum-graphite/epoxy) to provide a thermally stable structure. A computerized figure formation system is used to attain the approximate parabolic curve of each optic. Each optic is supported by ten titanium flexures to provide the necessary decoupling between the stiff structural support module and the glass mirrors. The design, analysis and fabrication of this module is described, as well as the numerous problems encountered and the solutions developed, in this protoflight project. Author

A88-13188
NOVEL COMPOSITE MATERIALS FOR SPACE STRUCTURES AND SYSTEMS
EDWARD J. A. POPE and JOHN D. MACKENZIE (California, University, Los Angeles) IN: Advanced materials technology '87; Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr. 6-9, 1987. Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 760-771. USAF-supported research. refs

Some novel composite materials that could be useful for space structure applications are reviewed. Criteria utilized in the selection of such materials are considered. Novel materials, such as hollow fiber/resin composites, transparent sol-gel-derived glass/polymer,

and new 'triphasic' composites made of ceramic, glass, and polymer phases are presented. Specific strength, specific modulus, vibrational damping, and other properties are examined. Author

A88-13189
FABRICATION AND ASSEMBLY OF AN ADVANCED COMPOSITE SPACE STATION TETRATRUSS CELL
MICHAEL J. ROBINSON (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: Advanced materials technology '87; Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr. 6-9, 1987. Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 772-781.

In a Space Station Phase B development effort, McDonnell Douglas Astronautics Company has fabricated a deployable tetratruss cell made almost entirely of graphite/epoxy composite materials. The cell consists of 24 struts, each 10 ft long, 15 of which bend in the middle to allow the cell to collapse. The strut tubes were fabricated with unidirectional prepregnated graphite tape. Hinge fittings, tube end fittings, and truss nodes were compression molded using tape and chopped fiber molding compounds. The fully deployed cell measures approximately 20 ft by 17.5 ft by 8.5 ft and collapses into a bundle 10 ft long and about 20 in in diameter. The manufacturing processes discussed include composite material layup and molding, assembly tooling design and fabrication, subassembly drilling and adhesive bonding operations, and final assembly. Author

A88-13929* Alabama Univ., Huntsville.
ROBUSTNESS OF ACTIVE MODAL DAMPING OF LARGE FLEXIBLE STRUCTURES
MICHAEL GREENE (Alabama, University, Huntsville) International Journal of Control (ISSN 0020-7179), vol. 46, Sept. 1987, p. 1009-1018. NASA-supported research. refs

The method of active modal damping (AMD) is reviewed, and the pinhole/occulter facility (P/OF) is presented as a design example. This system is a large space system composed of a flexible beam, a gimbal-pointing system, and an optical alignment system mounted in the Shuttle cargo bay and excited by typical Shuttle disturbances. The AMD system performance is compared with that of a series-compensated control system. C.D.

A88-13932* California Univ., Los Angeles.
DISTURBANCE AND VIBRATION ISOLATION IN SPACE STATIONS BY MEANS OF MECHANICAL DECOUPLING
P. K. C. WANG (California, University, Los Angeles) International Journal of Control (ISSN 0020-7179), vol. 46, Sept. 1987, p. 1061-1082. NASA-supported research. refs
(Contract NSF ECS-85-09145)

A decoupling approach to disturbance and vibration isolation in large space stations composed of modules interconnected by flexible members is proposed. A simplified mathematical model for the motion of the space station core and a laboratory module with both torsional vibration and translational motion decouplers is used in this study. The dynamic behavior of the model in the presence of decoupler friction is analyzed. Estimates for the maximum excursions of the laboratory module induced by various types of external disturbance are derived. The paper concludes with a simulation study involving the hard-docking of a space shuttle with a space station. Author

A88-15277
LARGE FLEXIBLE SOLAR ARRAYS
I. V. FRANKLIN (British Aerospace, PLC, Space and Communications Div., Bristol, England) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 18 p.

A description is given of a recent European achievement, the solar array for the Hubble Space Telescope which embodies several unique features which have relevance to the needs of Columbus. This is followed by a description of the objective of the present study which was to identify the preliminary design solutions for a 30 kW solar array working in LEO, considering both silicon and GaAs solar cells. The potential needs of the Columbus Resource Module were taken as a reference. The advantages of the double-H configuration flexible roll-out solar array are summarized. B.J.

A88-15278
ERM, THE DEPLOYABLE MAST FOR COLUMBUS
HERMANN RIEGER (Dornier System GmbH, Friedrichshafen, Federal Republic of Germany) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 18 p.

For application in the European Columbus project, the ERM (Extendable and Retractable Mast) has been selected as the most universal concept. Both the Resource Module and the Polar Platform require large solar generators of different sizes up to 18 kW. The modular design of the ERM can easily be adapted to different deployment lengths. Though the rollable array type has been chosen as the baseline, the ERM is also able to deploy rigid panel arrays. In addition the ERM will be used to position reflector antennas away from the module. The design is based on the telescopic principle using circular shaped graphite/epoxy tube sections for high stiffness and good thermal stability. The telescope is driven by a spindle/nut system, allowing the extension of the mast section by snction. Author

A88-15836*# National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.
RECENT ADVANCES IN STRUCTURAL DYNAMICS OF LARGE SPACE STRUCTURES
LARRY D. PINSON (NASA, Langley Research Center, Hampton, VA) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 22 p. refs
(IAF PAPER 87-51)

Recent progress in the area of structural dynamics of large space structures is reviewed. Topics include system identification, large angle slewing of flexible structures, definition of scaling limitations in structural models, and recent results on a tension-stabilized antenna concept known as the hoop-column. Increasingly complex laboratory experiments guide most of the activities leading to realistic technological developments. Theoretical progress in system identification based on system realization theory resulting in unification of several methods is reviewed. Experimental results from implementation of a theoretical large-angle slewing control approach are shown. Status and results of the development of a research computer program for analysis of the transient dynamics of large angle motion of flexible structures are presented. Correlation of results from analysis and vibration tests of the hoop-column antenna concept are summarized.
Author

A88-15967#
A GENERAL TRUSS SYSTEM FOR VERY LARGE SPACE BASE FOUNDATIONS, WITH APPLICATION TO THE SOLAR POWER SATELLITE
ANTHONY P. COPPA (General Electric Co., Astro Space Div., Philadelphia, PA) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 11 p. refs
(IAF PAPER 87-248)

The paper presents a general three-dimensional truss system (COPPATRUSS) that appears uniquely capable of satisfying the requirements for very large foundation structures in space. The currently patented system obtains perhaps the highest structural efficiency (strength/mass and stiffness/mass) possible in a general space truss. In addition it offers great architectural variety, modularity, fabrication economy, low package volume for launch, and rapid, principally automated, assembly in space. An example of an application to the Solar Power Satellite is discussed.
Author

A88-15974#
DEPLOYMENT DYNAMICS OF ACCORDIAN TYPE OF DEPLOYABLE SOLAR ARRAYS CONSIDERING FLEXIBILITY OF CLOSED CONTROL LOOPS
B. S. NATARAJU (Indian Space Research Organization, Satellite

Centre, Bangalore, India) and A. VIDYASAGAR IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 10 p.
(IAF PAPER 87-256)

An accordian type of deployment mechanism is under development for the deployment of solar arrays of the Indian Remote Sensing Satellite. A mathematical model for studying the effect of flexibility of Closed Control Loops (CCLs) on the deployment dynamics of such arrays has been formulated using Lagrange's method. The mathematical model involving dynamically coupled nonlinear simultaneous equations has been solved numerically after decoupling the second order terms using matrix transformation. This model has been used to choose a suitable spring in the CCLs to obtain a near synchronous deployment of the yoke and panels. Further, the effects due to variation of coefficient of friction, temperature and medium in which the arrays are deployed have been incorporated in the model. Author

A88-16011#
STRESS AND DEFORMATION ANALYSIS AND TESTS OF COMPOSITE STRUCTURES FOR SPACE APPLICATION
O. HAIDER and K. PFEIFER (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 15 p.
(IAF PAPER 87-312)

Stress tests and finite element analyses of composite structures for various space applications (including solar panels, antenna structures, and link connections in cryostats) are discussed. Tests were performed to determine the influence of the Young's modulus and the thicknesses of the face sheets and the core on the wrinkling stress of composite solar panels. FEM studies are used to design composite antenna structures with low thermal expansion coefficients. Glass and carbon composites with low thermal conductivity are used to design cryogenic links with small cross sections due to high tensile stress. R.R.

A88-16013#
LARGE INFLATABLE, SPACE-RIGIDIZED ANTENNA REFLECTORS - LAND MOBILE SERVICES DEVELOPMENT
M. C. BERNASCONI (Contraves AG, Zurich, Switzerland), E. PAGANA (Centro Studi e Laboratori Telecomunicazioni S.p.A., Turin, Italy), and G. G. REIBALDI (ESA, Mechanical Systems Div., Noordwijk, Netherlands) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 19 p. refs
(Contract ESA-5505/83/NL/PB; ESA-6244/85/NL/PB)
(IAF PAPER 87-315)

Inflatable, chemically rigidized space structures are applicable to a wide range of functions. A 2.8-m offset antenna reflector, for operation at 3.63 GHz, has been subjected to mechanical and electrical tests, to serve as a precursor for larger structures, such as those discussed for land mobile applications. Surface accuracies of 0.6 mm rms were achieved. Both folding and curing processes were found to have a negligible impact on the reflector's quality. The electrical performance has been shown to be predictable on the basis of the mechanical measurements. Author

A88-16015#
RESEARCH AND DEVELOPMENT OF THE TENSION TRUSS ANTENNA
KORYO MIURA, MASAMORI SAKAMAKI (Tokyo, University, Japan), TETSUO YASAKA, ISAO OHTOMO, JIN MITSUGI (Nippon Telegraph and Telephone Public Corp., Tokyo, Japan) et al. IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 10 p.
(IAF PAPER 87-317)

This paper presents the result of recent research and development of the tension truss antenna. The tension truss antenna is the deployable, mesh-surfaced space antenna, whose geodesic-truss-like reflector surface is realized by a pre-tensioned cable structure. A 3-m-diameter engineering model has been built for the purpose of identifying the technical problem area and testing the surface shape control algorithm. The principal feature of the tension truss antenna is that the surface shape is uniquely determined by the lengths and arrangement of truss cable composing the reflector surface, and is independent of the cable tension. An algorithm of surface shape control has been established taking advantage of this intrinsic nature of the concept. Any local deviation of the reflector surface can be adjusted by changing the length of said local cables and it does not influence the other part of the reflector. This algorithm has been tested using the model and the result has shown its effectiveness. In view of these results, the tension truss antenna has the potential for a variety of space antenna missions. Author

A88-16017#
TWO-DIMENSIONALLY DEPLOYABLE 'SHDF' TRUSS
JUNJIRO ONODA, NAOYUKI WATANABE, KAZUO ICHIDA (Tokyo, University, Japan), and HISASHI SAITO (Saito Co., Ltd., Tokyo, Japan) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 9 p. refs
(IAF PAPER 87-319)

The present paper describes a newly invented two-dimensionally deployable truss structure named SHDF, which has no articulated members. The most significant feature of SHDF truss is the very small number of the mechanisms to be actuated and locked at the deployment. A globally flat functional model actuated by tiny electromagnetic motors was designed and fabricated. The model demonstrated its practicality and virtually synchronized smooth motion in deploy/fold tests. Subsequently, the model was reformed into a globally parabolic configuration and combined with a one-dimensionally deployable truss named SHSF, which is also newly invented. Further deploy/fold tests similarly demonstrated the practicality of parabolic SHDF truss structure and the compatibility of SHDF with SHSF. Author

A88-16018#
CAPABILITIES AND SPECIAL FEATURES CONCERNING STRUCTURAL OPTIMIZATION OF SPACECRAFT STRUCTURES
PETER MIKOLAJ (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 12 p. refs
(IAF PAPER 87-320)

The program architecture and implementation of the MBB-LAGRANGE program for the structural optimization of spacecraft structures are discussed. Several optimization algorithms are implemented which are capable of handling both large scale sizing problems and small scale geometry problems. The program uses the FEM for analysis and Mathematical Programming or Optimality Criteria for the optimization algorithms. The efficiency of the process is demonstrated with examples including a NASA plate-optimization problem, a satellite coolplate, and an Ariane 5/Eureka adaptor. R.R.

A88-16019#
SENSITIVITY ANALYSIS AND OPTIMAL DESIGN FOR LARGE UNRESTRAINED STRUCTURES
N. V. BANICHUK and E. V. MAKEEV (AN SSSR, Institut Problem Mekhaniki, Moscow, USSR) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 12 p. refs
(IAF PAPER 87-321)

An efficient sensitivity analysis method is proposed for calculating basic functional variations depending on variations in mass and stiffness. The method, which is based on the use of adjoint variables and adjoint systems of equations, makes it possible to define domains in a structure where redesign should be most effective. To calculate the dynamic behavior of large unrestrained structures, use is made of the modal analysis method; the eigenfrequencies and eigenmodes of free vibrations are determined by the perturbation method and a subspace iteration technique taking into account the properties of sparse matrices. The problem of rational material distribution in large space structures is also discussed, and some numerical examples are presented. V.L.

A88-16038#
A UNIFIED MATRIX APPROACH APPLIED TO DYNAMIC FORMULATION OF COMPLEX SPACE STRUCTURES WITH NONLINEAR HINGE FORCES AND TORQUES
Y. OHKAMI, O. OKAMOTO, T. KIDA, and I. YAMAGUCHI (National Aerospace Laboratory, Chofu, Japan) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 10 p. refs
(IAF PAPER 87-348)

In the present approach to a dynamical modeling of nonlinear hinge forces and torques for complex space structures, using the unified matrix method, emphasis is placed on the precise expression of both the relative displacements and velocities and the internal forces and torques at the hinges connecting two adjacent bodies. A computer code has been developed by means of which realistic simulation models can be implemented without cumbersome manipulation of mathematical relations. Illustrative latch-up and limiter mechanisms are presented for a space structure manipulator. O.C.

A88-16046#
REDUCED ORDER MODELS OF A LARGE FLEXIBLE SPACECRAFT
KAZUO TSUCHIYA, TOSHIO KASHIWASE, and KATSUHIKO YAMADA (Mitsubishi Electric Corp., Central Research Laboratory, Amagasaki, Japan) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 5 p. refs
(IAF PAPER 87-356)

Two reduced-order models of a large flexible spacecraft are proposed. The first one is expressed in terms of the modes of static deformation of the spacecraft and the normal modes of vibration of the spacecraft. The reduced-order model can express the dynamical behavior of the spacecraft accurately in a low frequency region with proper choice of the modes of static deformation of the spacecraft. The second one is suited for a class of spacecraft composed of the main body with subbodies. The reduced-order model is expressed in terms of two sets of the normal modes of vibration, the normal modes of the whole spacecraft and the normal modes of the subbodies. The reduced order model can easily cope with the change of the structures of the subbodies. These reduced order models are illustrated through application to a simple spacecraft model. Author

A88-16292
MODAL DAMPING MEASUREMENT OF MOS-1 SOLAR ARRAY PADDLE
Y. FUJIMORI (National Space Development Agency of Japan, Tokyo), J. KATO, S. MOTOHASHI, F. KUWAO, and S. SEKIMOTO (Toshiba Corp., Kawasaki, Japan) IN: Automatic control in space 1985. Oxford and New York, Pergamon Press, 1986, p. 121-125. refs

Dynamic test on the MOS-1 satellite's paddle structure was conducted to measure damping coefficients of the lower three modes. Precautions against the effect of the gravity force, interface damping, suspension cable length and data processing software on the test results are carefully taken, so that the data survive severe technical scrutinies. The dynamic characteristics of the solar array drive and power transmission assembly in the torsional direction was examined separately in an open room. The experimental results of the damping coefficients are analytically extrapolated to the on-orbit values; 1.1, 0.4, and 0.45 percent for 1st, 2nd and 3rd modes, respectively. Author

A88-16293
MATHEMATICAL MODELS OF FLEXIBLE SPACECRAFT DYNAMICS - A SURVEY OF ORDER REDUCTION APPROACHES
P. TH. L. M. VAN WOERKOM (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Automatic control in space 1985. Oxford and New York, Pergamon Press, 1986, p. 127-135. Research supported by the Nederlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart. refs

Approaches to open loop model order reduction are evaluated with a view to the reduction of spacecraft mathematical dynamics model complexity. These approaches may be characterized as those of (1) parameter optimization, (2) aggregation, (3) singular perturbation, (4) modal dominance, (5) component cost analysis, and (6) internal balancing. The latter three approaches are judged to be the most significant, and are applied to the case of a long flexible beam in space that is controlled by two line torquers. O.C.

A88-16990
DEVELOPMENT OF THE MAST FLIGHT SYSTEM LINEAR DC MOTOR INERTIAL ACTUATOR
J. W. SHIPLEY, L. D. DAVIS, W. T. BURTON, and F. M. HAM (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: Guidance and control 1987; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Jan. 31-Feb. 4, 1987. San Diego, CA, Univelt, Inc., 1987, p. 237-255.
(AAS PAPER 87-021)

A linear dc motor (LDCM) inertial actuator is being developed for use on the Mast Flight System. Both tip mounted and intermediate station mast actuators will employ this concept. Excitation, damping and structural control will be accomplished using these actuators. Performance goals have been established for the LDCM which will insure that the Mast Flight System will meet its objective as a test bed for development and verification of controls/structures interaction (CSI). The design goals involve force output, frequency response, waveform distortion, dynamic range, drift compensation and packaging. The present paper discusses the design and development of the LDCM. In particular, command and compensation strategy trades, sensor resolution requirements and motor commutation techniques are considered. Also development of a compound pendulum test bed which emulates low frequency dynamics of the Mast Flight System is reviewed, and test results are presented on excursion performance and baseline damping algorithm performance. Author

A88-16996* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
LARGE SPACE STRUCTURES TESTING
HENRY WAITES (NASA, Marshall Space Flight Center, Huntsville, AL) and H. EUGENE WORLEY (Control Dynamics Co., Huntsville, AL) IN: Guidance and control 1987; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Jan. 31-Feb. 4, 1987. San Diego, CA, Univelt, Inc., 1987, p. 353-370. Previously announced in STAR as N87-24520.
(AAS PAPER 87-036)

There is considerable interest in the development of testing concepts and facilities that accurately simulate the pathologies believed to exist in future spacecraft. Both the Government and industry have participated in the development of facilities over the past several years. The progress and problems associated with the development of the Large Space Structure Test Facility at the Marshall Flight Center are presented. This facility was in existence for a number of years and its utilization has run the gamut from total in-house involvement, third party contractor testing, to the mutual participation of other goverment agencies in joint endeavors. Author

A88-17599
A NEAR FIELD TEST SYSTEM FOR VERY LARGE ANTENNAS
P. J. WOOD (Canadian Astronautics, Ltd., Ottawa, Canada) IN: International Conference on Antennas and Propagation, 5th, York, England, Mar. 30-Apr. 2, 1987, Proceedings. Part 1. London, Institution of Electrical Engineers, 1987, p. 489-492.

Some problems associated with the selection of a near field test system for the Canadian Radarsat satellite, a C-band planar array of 1.5x15 m, are examined. On the basis of considerations such as ease of implementation, measurement time, and accuracy, the cylindrical method is found to be more suitable than the planar one. A special version of the cylindrical method is described wherein the cylinder axis is horizontal, linear probing is carried out in

overlapping subdomains, and the linear motion is the fast motion of the two-dimensional raster scan.
V.L.

A88-18173#
MONITORING ELASTIC STIFFNESS DEGRADATION IN GRAPHITE/EPOXY COMPOSITES
R. D. KRIZ (NBS, Fracture and Deformation Div., Boulder, CO) IN: Solid mechanics research for quantitative non-destructive evaluation. Dordrecht, Martinus Nijhoff Publishers, 1987, p. 389-395. refs

Many stiffness-critical aerospace structures exploit the high specific stiffness of graphite/epoxy composites. Elastic-stiffness degradation of these materials is therefore important. Here, a nondestructive technique is described that measures stiffness degradation of the graphite-fibers and epoxy-matrix. This technique monitors variations in the direction of stress-wave propagation (energy-flux) corresponding to a change in composite stiffness.
Author

A88-18632#
FINITE-ELEMENT MODEL FOR THE THERMOELASTIC ANALYSIS OF LARGE COMPOSITE SPACE STRUCTURES
J. D. LUTZ, D. H. ALLEN, and W. E. HAISLER (Texas A & M University, College Station) (Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1, p. 96-102) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, Sept.-Oct. 1987, p. 430-436. Previously cited in issue 18, p. 2616, Accession no. A86-38811. refs
(Contract F49620-83-C-0067)

A88-18637*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VERIFICATION OF LARGE BEAM-TYPE SPACE STRUCTURES
CHOON-FOO SHIH (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) (Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1, p. 78-84) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, Sept.-Oct. 1987, p. 469-473. Previously cited in issue 18, p. 2654, Accession no. A86-38809. refs

A88-20908
APPLICATION OF PERTURBATION TECHNIQUES TO FLEXIBLE MULTIBODY SYSTEM DYNAMICS
LU YOU FANG, A. A. SHABANA (Illinois, University, Chicago), and OM P. AGRAWAL (Southern Illinois, University, Carbondale, IL) Computers and Structures (ISSN 0045-7949), vol. 27, no. 5, 1987, p. 631-637. refs

In this paper, a matrix perturbation technique is developed for flexible bodies (substructures) that undergo large reference translational and rotational displacements. Although the governing dynamic equations of motion of such systems are highly nonlinear because of the large angular rotations and the resulting nonlinear inertia coupling between the reference motion and the elastic deformation, a generalized linear eigenvalue problem that defines the deformation mode shapes of the body with respect to the selected body reference is identified. This eigenvalue problem is solved only once and the variations in the body stiffness and inertia properties due to a change in selected design parameters are evaluated by using perturbation analysis techniques. The main advantage of using the proposed technique is to avoid a new finite element discretization when some design parameters are changed. This, in turn, substantially reduces the computational time, especially when large scale flexible bodies with complex geometry are considered. A numerical example is presented in order to demonstrate the use of the perturbation techniques developed in this paper in the design of flexible multibody systems.
Author

A88-21221
FORMULATION OF RIGID MULTIBODY SYSTEMS IN SPACE
KATSUHIKO YAMADA and KAZUO TSUCHIYA (Mitsubishi Electric Corp., Central Research Laboratory, Amagasaki, Japan) JSME International Journal (ISSN 0913-185X), vol. 30, Oct. 1987, p. 1667-1674. refs

The equations of motion of rigid multibody systems, such as space structures whose bases are free, are derived using the equations of motion of Kane et al. (1983). The equations of motion which set the position of the center mass of one body as generalized coordinates are first obtained. A technique for deriving the equations of motion which set the position of the center of mass of the system as generalized coordinates is then proposed in which the orbital motion and the attitude motion are treated separately. The method is shown to be applicable not only for the tree configuration system, but also for the loop configuration system with cutting loops, using Lagrange's multipliers as constrained forces.
R.R.

A88-21521#
FUTURE IN-ORBIT TECHNOLOGY DEMONSTRATIONS
H. STOEWER and G. G. REIBALDI (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) ESA Bulletin (ISSN 0376-4265), no. 52, Nov. 1987, p. 22-29.

The First Phase of the ESA In-Orbit Technology Demonstration Programme was initiated in 1987 and is scheduled to be completed in 1990. This Programme is considered with respect to experiments of common interest to existing and future programs (materials, dynamics of flexible structures, and AOCS thrusters and propellants); support for the development and utilization of new programs (rendezvous and docking, fluid management, EVA, thermal control, reentry, life support, and robotics); performance testing (antennas, sensors, and propulsion); and Columbus as a carrier for technology experiments.
B.J.

A88-22286#
LARGE SPACE SYSTEMS ENVIRONMENTAL ENTANGLEMENTS
CARL J. FRUSHON and JOHN A. GAUDET (USAF, Geophysics Laboratory, Bedford, MA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 27 p. refs
(AIAA PAPER 88-0388)

The most important adverse environmental impacts on future space systems are identified and discussed. Charging, radiation, contamination, atomic oxygen erosion, particle impacts, high-voltage interactions, and thermal forces are considered. Research on ways to mitigate these forces and counteract their adverse impacts is addressed.
C.D.

A88-22321#
SHUTTLE EXPERIMENTS TO MEASURE THE OPTICAL ENVIRONMENTS SURROUNDING LARGE SPACE STRUCTURES
BYRON DAVID GREEN, GEORGE E. CALEDONIA, ANDREW LINTZ, JAMES PERSON, PRAKASH JOSHI (Physical Sciences, Inc., Andover, MA) et al. AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 7 p. refs
(AIAA PAPER 88-0432)

This paper describes two projects which will probe different aspects of the environment surrounding spacecraft in low-earth orbit. Both are presently in the design stage. The first, the GLOS/SKIRT payload, will measure the spacecraft glow across the ultraviolet to mid-infrared spectral regions. The second payload will attempt to prove the Critical Ionization Velocity hypothesis and will monitor electrostatic and optical emissions generated by the interaction of released gases with the ionosphere.
Author

A88-22486*# National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.
THE X-RAY LARGE ARAY. II - IMPLEMENTATION
JOSEPH DABBS, BILLY DAVIS, and JOHN DAVIS (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 6 p.
(AIAA PAPER 88-0654)

The design of the X-ray Large Array (XLA) which is to be assembled and operated in space is discussed. The XLA is a 100

sq m array of 64 detector modules with a total of 512 detectors, each similar to the ones flown on the HEAO-1 spacecraft, packaged in groups of eight to form a module. The XLA will be able to deal with many extremely fast processes which occur in compact X-ray sources and will be used to study black hole candidates; its fine time resolution will make it possible to resolve the spatial structure of celestial X-ray sources using lunar occultation, the angular structure of quasars, and active galactic nuclei. Details of the XLA configuration, and the assembly and packaging options are described together with systems requirements. Multiple configuration diagrams are included. I.S.

A88-22608#
DISTRIBUTED SYSTEMS APPROACH TO THE IDENTIFICATION OF FLEXIBLE STRUCTURES
K. Y. LEE (Pennsylvania State University, University Park) and S. A. HOSSAIN (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, Nov.-Dec. 1987, p. 540-548. refs

This paper presents a distributed parameter estimation scheme and investigates its computational merit for three idealized examples of the identification of large flexible structures. The method retains the distributed nature of the structure throughout the development of the algorithm and a finite-element approximation is used only to implement the algorithm. This approach elimnates many problems associated with the model truncation used in other methods of identification. The identification problem is formulated in Hilbert spaces and an optimal control technique is used to minimize a weighted least squares of error between the actual and the model data. A variational approach is used to solve the problem. A costate equation, gradients of parameter variations and conditions for optimal estimates are obtained. Computer simulation studies are conducted using flexible beam models as examples. Numerical results show a close match between the estimated and true values of the parameters.
Author

A88-27148
SYNTHESIS OF THE FLEXIBLE STRUCTURES OF COMPLEX SYSTEMS [SINTEZ GIBKIKH STRUKTUR SLOZHNYKH SISTEM]
M. A. MUZIUKIN and V. K. AKINFIEV IN: Methods for the optimization of complex systems. Moscow, Izdatel'stvo Nauka, 1987, p. 54-63. In Russian.

The problem of improving the structure and increasing the efficiency of globally distributed information/control systems is examined with particular reference to the automatic control systems of flight vehicles. The problem of the synthesis of the flexible structure of complex systems is formulated as a nonlinear mathematical programming problem. An optimization-simulation approach to the solution of such problems is proposed which involves the development of procedures using optimization and simulation or computational models for the synthesis of the optimal version of the structure. V.L.

A88-27319* Texas Univ., Austin.
A PARAMETER ROBUST LQG DESIGN SYNTHESIS WITH APPLICATIONS TO CONTROL OF FLEXIBLE STRUCTURES
MINJEA TAHK and JASON L. SPEYER (Texas, University, Austin) IN: 1987 American Control Conference, 6th, Minneapolis, MN, June 10-12, 1987, Proceedings. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1987, p. 386-392. NASA-supported research. refs
(Contract AF-AFOSR-84-0371)

An asymptotic LQG design synthesis technique is described which explicitly includes a class of structured plant uncertainties by viewing plant parameter variations as an internal feedback loop. A direct structural relationship between this class of parameter uncertainties and the weighting matrices in the design of the LQG compensator is exploited by an asymptotic procedure in which either the regulator or the filter become insensitive to parameter variations. This asymptotic approach represents a generalization of the LQG/LTR technique. Controllers designed by this new LQG method and LQG/LTR are compared by application to a mass-spring-damper system which approximates the dynamics of flexible structures. For both colocated and noncolocated sensors and actuators configurations, the LQG/LTR design is extremely sensitive to parameter variations whereas the new LQG design allows considerably improved parameter robustness. Author

A88-27325
ROBUST STABILIZATION UNDER MODE TRUNCATION AND PARAMETER VARIATIONS
RAMA K. YEDAVALLI (Toledo, University, OH) IN: 1987 American Control Conference, 6th, Minneapolis, MN, June 10-12, 1987, Proceedings. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1987, p. 490-495. refs
(Contract F33615-86-K-3611)

This paper addresses the issue of stability robustness under mode truncation and parameter variations with emphasis on Large Space Structures (LSS) models. The recent development of elemental (structured) upper bounds on the perturbation of an asymptotically stable linear system to maintain stability is extended to the problem of LSS control in which both mode truncation (model reduction) as well as parameter variations (uncertainty in modal frequencies, dampings, and mode shape slopes at actuator/sensor locations) are considered as perturbations acting on the control design model. A simple algorithm is proposed to design a robust controller, with vibration suppression as the control objective, for robust stability and acceptable nominal performance under mode truncation and parameter errors. The algorithm is such that it clearly delineates the trade off between the control effort needed for acceptable regulation and the number of modes one needs to control for robust stability. Author

A88-27356
DECENTRALIZED CONTROL OF THIRD GENERATION SPACECRAFT
E. J. DAVISON (Toronto, University, Canada) and W. GESING (Citibank Canada, Toronto) IN: 1987 American Control Conference, 6th, Minneapolis, MN, June 10-12, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1987, p. 963-969. refs
(Contract CDC-DSS-37ST,36001-5-3552)

A brief summary is given of a study on the decentralized control system design of a third-generation spacecraft as modeled by the MSAT vehicle configuration. Representative output simulations are given. Results obtained using centralized control are presented which show that the decentralized design is highly effective compared to the centralized case. C.D.

A88-27357
ACTIVE VIBRATION CONTROL ON THE OSU FLEXIBLE BEAM
UMIT OZGUNER and STEVE YURKOVICH (Ohio State University, Columbus) IN: 1987 American Control Conference, 6th, Minneapolis, MN, June 10-12, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1987, p. 970-975. Research supported by Ohio State University. refs

The idea of actively damping vibrations in flexible structure systems has received much attention in recent years. Such systems present a particular problem in that there is no fixed frame of reference for actuation; actuators must then be mounted on the structure itself. Currently at Ohio State a laboratory facility is being developed to study control of flexible structures; one specific configuration is a six foot free-free beam which is suspended from the ceiling. Such a beam can be controlled by applying torques about the bending axis or by applying transverse forces. Due to the size constraints of such a laboratory-scale experiment, a small structure with small actuators and sensing devices is utilized. Transverse actuators (developed in-house) were chosen for the experiment, and sensing is accomplished via several sets of strain gauges and accelerometers mounted on the structure. This paper discusses issues involved with the modeling of this structure, and presents a brief summary of the various control approaches,

primarily from a decentralized viewpoint, which are currently being applied to the laboratory setup. Author

A88-27359* Virginia Polytechnic Inst. and State Univ., Blacksburg.
A SURVEY OF DECENTRALIZED CONTROL TECHNIQUES FOR LARGE SPACE STRUCTURES
D. K. LINDNER and K. REICHARD (Virginia Polytechnic Institute and State University, Blacksburg) IN: 1987 American Control Conference, 6th, Minneapolis, MN, June 10-12, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1987, p. 982-985. refs
(Contract NAS1-18106)

Preliminary results on the design of decentralized controllers for the COFS I Mast are reported. A nine mode finite element model is used along with second order model of the actuators. It is shown that without actuator dynamics, the system is stable with co-located rate feedback and has acceptable performace. However, when actuator dynamics are included, the system is unstable. Author

A88-27377
CONTROL OF DISTRIBUTED PARAMETER SYSTEMS WITH SPILLOVER USING AN AUGMENTED OBSERVER
YOSSI CHAIT and CLARK J. RADCLIFFE (Michigan State University, East Lansing) IN: 1987 American Control Conference, 6th, Minneapolis, MN, June 10-12, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1987, p. 1193-1198. refs

Modern modal control methods for flexible structures, based on a truncated model of the structure's dynamics, have control and observation spillover which can reduce the stability margin of the controlled structure. Here, a standard model formulation of a distributed-parameter system is presented along with conventional control methods. The spillover phenomenon is defined, and the advantages and disadvantages of sensor output filtering are examined. A new design for a modern modal control system with an output filter augmented into the observer is developed. A comparison between the different control methods is made using a numerical example. C.D.

A88-27395
ACTIVE MODIFICATION OF WAVE REFLECTION AND TRANSMISSION IN FLEXIBLE STRUCTURES
DAVID W. MILLER, ANDREAS VON FLOTOW, and STEVEN R. HALL (MIT, Cambridge, MA) IN: 1987 American Control Conference, 6th, Minneapolis, MN, June 10-12, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1987, p. 1318-1324. refs

A theory for active control of elastic wave propagation in structures is developed. Attention is focused on active modification of the scattering behavior of discrete locations in a structural network. The wave mode input/output relation at a structural junction containing control actuators can be altered in two ways. First, the closed loop reflection and transmission coefficients can be specified, and the necessary feedback to achieve these coefficients determined. Second, an optimal wave controller can be formulated which maximizes the average power dissipation at a junction. If the open loop structure is stable, then the optimal control guarantees stability, since energy is actively dissipated at the junction. Sample controllers are derived and simulated for a free-free beam to demonstrate the techniques and indicate the achievable performance. Author

A88-27401
A HOMOTOPY ALGORITHM FOR SOLVING THE OPTIMAL PROJECTION EQUATIONS FOR FIXED-ORDER DYNAMIC COMPENSATION - EXISTENCE, CONVERGENCE AND GLOBAL OPTIMALITY
STEPHEN RICHTER (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: 1987 American Control Conference, 6th, Minneapolis, MN, June 10-12, 1987, Proceedings. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1987, p. 1527-1531. refs
(Contract F49620-86-C-0038)

A homotopy algorithm for solving the optimal projection equations (OPEs), relevant to the problem of vibration suppression in large flexible space structures, is presented. The existence and the number of solutions are investigated. It is shown that the number of stabilizing solutions to the OPEs can be determined and that all solutions can be computed via a homotopic continuation from a simple problem. For an important special case, where the number of inputs or outputs to the system is less than or equal to the dimension of the compensator, there is only one solution to the OPE, guaranteeing that globally optimum reduced order controller can be computed. C.D.

A88-28042#
OPTIMUM DESIGN OF STRUCTURES WITH MULTIPLE CONSTRAINTS
R. A. CANFIELD, V. B. VENKAYYA (USAF, Wright-Patterson AFB, OH), and R. V. GRANDHI (Wright State University, Dayton, OH) (Structures, Structural Dynamics, and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1, p. 398-408) AIAA Journal (ISSN 0001-1452), vol. 26, Jan. 1988, p. 78-85. USAF-supported research. Previously cited in issue 18, p. 2617, Accession no. A86-38845. refs

A88-28509#
DYNAMICS OF LARGE CONSTRAINED FLEXIBLE STRUCTURES
F. M. L. AMIROUCHE (Illinois, University, Chicago) and R. L. HUSTON (Cincinnati, University, OH) ASME, Transactions, Journal of Dynamic Systems, Measurement and Control (ISSN 0022-0434), vol. 110, March 1988, p. 78-83. refs

This paper presents an automated procedure useful in the study of large constrained flexible structures, undergoing large specified motions. The structure is looked upon as a 'partially open tree' system, containing closed loops in some of the branches. The governing equations are developed using Kane's equations as formulated by Huston et al. The accommodation of the constraint equations is based on the use of orthogonal complement arrays. The flexibility and oscillations of the bodies is modeled using finite segment modeling, structure analysis, and scaling techniques. The procedures developed are expected to be useful in applications including robotics, space structures, and biosystems. Author

A88-29474
INTEGRATED CONTROL OF LARGE FLEXIBLE STRUCTURES
GLORIA CAPITANI and MARCO TIBALDI (Bologna, Universita, Italy) International Journal of Control (ISSN 0020-7179), vol. 47, Feb. 1988, p. 569-580. refs

A procedure for the design of algebraic feedback that aims to improve the stability of flexible structures is presented. This algebraic controller design can be integrated into the design of a reduced-order dynamic controller. The algebraic feedback design is developed and improved from earlier works. An application to the solar optical telescope (SOT) model is shown. Author

A88-29720
A CRITERION FOR SHAPE CONTROL ROBUSTNESS OF SPACE STRUCTURES
MENAHEM BARUCH (Technion - Israel Institute of Technology, Haifa) Zeitschrift fuer angewandte Mathematik und Physik (ISSN 0044-2275), vol. 39, Jan. 1988, p. 84-95. Research supported by Technion - Israel Institute of Technology. refs

The procedure proposed by Baruch (1985) for designing space-structure static-deformation controls without knowledge of the structure mass is rederived, and a robustness criterion for such shape controls is developed analytically. The robustness criterion is defined in terms of the spectral condition number with respect to inversion (Wilkinson, 1965) of the basic matrix A; its usefulness is demonstrated in a numerical example involving a free beam modeled as a 5-DOF discrete structure. T.K.

A88-29725
STRUCTURAL TESTING ON THE MULTI-AXIS SIMULATOR - AN INNOVATIVE SIMULATION SYSTEM FOR SPACE-VEHICLE STRUCTURES
New-Tech News, no. 1, 1988, p. 28-30.

The multiaxis simulator presented is an innovative test apparatus for the verification of spacecraft structures' ability to withstand periods of high stress; it also ascertains where a structural system's design dimensions may be further reduced, in the interest of weight savings, without compromising the safety margins of structural integrity. The transient vibrations in six axes simulated with the apparatus correspond to forces acting on the spacecraft during launch and flight; the system is sufficiently ample to allow testing of major subcomponents of large structures. O.C.

A88-29815*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SOME EXPERIENCES WITH THE EIGENSYSTEM REALIZATION ALGORITHM
RICHARD S. PAPPA and JER-NAN JUANG (NASA, Langley Research Center, Hampton, VA) Union College and SEM, International Modal Analysis Conference, 6th, Orlando, FL, Feb. 1-4, 1988, Paper. 8 p. refs

The Eigensystem Realization Algorithm (ERA) is a multiinput/multioutput time-domain algorithm for minimum-order system realization and modal parameter identification. It has been used for structural dynamics data analysis at the Langley Research Center for several years. Some of the practical experiences encountered in these projects are discussed in this paper. Three examples are used: the Galileo spacecraft, the Solar Array Flight Experiment, and a laboratory space-truss model. Several techniques for assessing identification accuracy are illustrated. Author

A88-29819*# PRC Kentron, Inc., Hampton, Va.
AN APPLICATION OF MSC/NASTRAN IN THE INTERDISCIPLINARY ANALYSIS OF LARGE SPACE-BASED STRUCTURES
ALAN E. STOCKWELL, MARETA W. CHAMBERS (PRC Kentron, Inc., Hampton, VA), and PAUL A. COOPER (NASA, Langley Research Center, Hampton, VA) MSC World Users Conference, Los Angeles, CA, Mar. 21-25, 1988, Paper. 27 p.

The Integrated Multidisciplinary Analysis Tool (IMAT), a computer software system developed at NASA Langley to analyze and simulate the dynamics of space-structure/control-system interactions, is described, and its application to the MAST problem (a 60-m truss with fundamental frequency less than 200 mHz and equipped with linear proof-mass actuators, to be deployed from the Space Shuttle as part of COFS-I flight experiment) is demonstrated. Particular attention is given to the IMAT procedures which facilitate the use of the MCS/NASTRAN code to recover physical results from time-domain state-space solutions obtained with an FEM control-design code. Diagrams, drawings, and graphs are provided. T.K.

A88-30999*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LARGE SPACE STRUCTURES - STRUCTURAL CONCEPTS AND MATERIALS
CHARLES P. BLANKENSHIP and ROBERT J. HAYDUK (NASA, Langley Research Center, Hampton, VA) SAE, International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987. 30 p. refs
(SAE PAPER 872429)

Large space structures will be a key element of the future space activities. They will include spacecraft such as the planned Space Station and large antenna/reflector structures for communications and observations. These large structures will exceed 100 m in length or 30 m in diameter. Concepts for construction of these spacecraft on orbit and their materials of construction provide some unique research challenges. This paper will provide an overview of the research in space construction of large structures including erectable and deployable concepts. Also, an approach to automated, on-orbit construction will be presented. Materials research for space applications focuses on high stiffness, low expansion composite materials that provide adequate durability in the space environment. The status of these materials research activities will be discussed. Author

A88-31376
AIAA SDM ISSUES OF THE INTERNATIONAL SPACE STATION, CONFERENCE, WILLIAMSBURG, VA, APR. 21, 22, 1988, TECHNICAL PAPERS
Conference sponsored by AIAA. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, 200 p. For individual items see A88-31377 to A88-31385, A88-31387 to A88-31399.

Various papers on the International Space Station (SS) are presented. The topics discussed include: structures and materials technology for the SS, measurement and modeling of joint damping in space structures, Shuttle-based assembly of the SS, design and development of the truss assembly fixture for SS assembly operations, EVA construction and repair of tubular system on the SS, astronaut/EVA construction error detection in large space structures, nondestructive construction error detection in large space structures, damage detection and location in large space trusses, steady state micro-G environment on the SS, and hypervelocity impact damage assessment for the SS. Also addressed are: development and properties of aluminum-clad graphite/epoxy tubes for space structures, response of composite materials to the SS orbit environment, spillover stabilization of large space structures, dynamics and control characteristics of a reference SS configuration, impact of asymmetric physical properties on large space structures, SS pressure wall repair techniques, long-life assurance for SS, and orbit lifetime characteristics for the SS. C.D.

A88-31377*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STRUCTURES AND MATERIALS TECHNOLOGY FOR SPACE STATION
CHARLES P. BLANKENSHIP and JAMES C. YU (NASA, Langley Research Center, Hampton, VA) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1-6. refs
(AIAA PAPER 88-2446)

This paper provides a brief overview of the NASA Langley structures and materials technology program for large space structures. Concepts developed for constructing large space truss structures such as space platforms and antennas are considered. The applications of the finding to the Space Station initiative are addressed. C.D.

A88-31378#
MEASUREMENT AND MODELING OF JOINT DAMPING IN SPACE STRUCTURES
STEVEN L. FOLKMAN and FRANK J. REDD (Utah State University, Logan) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 7-13. refs
(AIAA PAPER 88-2449)

An area of concern for the design of large space structures is the amount of structural damping which will be present. The joints used to assemble a large, light weight structure like the Space Station will provide some damping; however, an accepted methodology for predicting joint damping is yet to be established. This paper documents a research effort at Utah State University to better understand joint damping in large space structures. A miniature tetrahedral truss was constructed which used pinned joints. A large tip mass was attached to the truss to lower the natural frequency to a range associated with the space station. Considerable ground testing has been conducted to characterize the damping of the truss in a 1-g environment in different orientations and in a vacuum. These experiments show that gravity can dramatically influence the damping produced. Author

A88-31380#
DESIGN AND DEVELOPMENT OF THE TRUSS ASSEMBLY FIXTURE FOR SPACE STATION ASSEMBLY OPERATIONS
CHARLES SCOTT MACGILLIVRAY (Rockwell International Corp., Satellite and Space Electronics Div., Seal Beach, CA) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 23-31.
(AIAA PAPER 88-2455)

This paper describes the Truss Assembly Fixture design evolution based on the state of on-orbit assembly technology and the Space Station design. The main design requirements and constraints are identified, and interfacing systems are discussed. The results of testing performed to date, including full-scale engineering mockup evaluations in both laboratory and underwater neutral buoyancy environments, are discussed. C.D.

A88-31383*# Texas A&M Univ., College Station.
NONDESTRUCTIVE CONSTRUCTION ERROR DETECTION IN LARGE SPACE STRUCTURES
NORRIS STUBBS (Texas A & M University, College Station), TAFT H. BROOME (Howard University, Washington, DC), and ROBERTO OSEGUEDA (Texas, University, El Paso) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 47-55. Research supported by Texas A & M University. refs
(Contract NAG1-383)
(AIAA PAPER 88-2460)

Continuum modeling of large space structures is extended to the problem of detecting construction errors in large space structures such as the proposed space station. First-order dynamic sensitivity equations for structures involving eigentrequencies, modal masses, modal stiffnesses, and modal damping are presented. Matrix equations relating changes in element parameters to dynamic sensitivities are summarized. The sensitivity equations for the entire dynamical system are rearranged as a system of algebraic equations with unknowns of stiffness losses at selected locations. The feasibility of the formulation is numerically demonstrated on a simply-supported Euler-Bernoulli beam with simulated construction defects. The method is next extended to large space structures modelled as equivalent continua with simulated construction defects. Author

A88-31384#
DAMAGE DETECTION AND LOCATION IN LARGE SPACE TRUSSES
SCOTT L. HENDRICKS (Virginia Polytechnic Institute and State University, Blacksburg) and SUZANNE WEAVER SMITH IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 56-63. refs
(AIAA PAPER 88-2461)

Research toward the eventual construction of large space structures includes a considerable amount of work on the topic of damage. The focus of this work is detection and location of damage in large truss structures. A method has been developed which incorporates system identification techniques using dynamic response measurements with a damage location algorithm to pinpoint deleted members of a truss. Various damage cases are examined in simulations with two truss structures: a planar truss and a three dimensional orthogonal tetrahedral truss similar to that proposed for the Space Station. The simulation results show that damage can be located by using the response of a large truss structure. However, damage in certain members is difficult or impossible to locate with limited available data. Author

A88-31387#
SPACE STATION PROBABILITY OF NO PENETRATION DUE TO METEOROID AND ORBITAL DEBRIS IMPACT
M. A. WRIGHT, A. R. CORONADO, and P. H. STERN (Boeing Aerospace Co., Seattle, WA) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 82-89. refs
(AIAA PAPER 88-2464)

An analysis technique and associated computer programs have been developed that predict the probability of no penetration of a spacecraft subject to meteoroid or man-made orbital debris impact. This technique accounts for the spacecraft's geometry, orientation, varying wall configuration and the varying density of the meteoroid and debris environment. Results are presented for a configuration similar to the proposed Space Station. These results show that the Space Station will require shields to obtain adequate safety levels. This shielding will be primarily designed by the debris threat. The results are sensitive to the environment definition and wall penetration function. Author

A88-31388*# Boeing Aerospace Co., Seattle, Wash.
HYPERVELOCITY IMPACT DAMAGE ASSESSMENT FOR SPACE STATION
ALEX R. CORONADO, MARTIN N. GIBBINS, and PAUL H. STERN (Boeing Aerospace Co., Seattle, WA) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 90-98. refs
(Contract NAS8-36426)
(AIAA PAPER 88-2465)

To inhibit damage and limit the probability of penetration of the Space Station pressure wall by micrometeoroids and orbital debris, a shield placed away from the wall is used to form a double wall. To determine shield effectiveness and assess impact damage, existing test data were reviewed and additional testing was performed for Space Station double wall designs. Empirical spallation and penetration functions derived from the data show that shield thickness and impact angle affect the damage to the wall. Thick shields reduce wall damage for low angle impacts but increase damage for oblique impacts. Multilayer insulation between the shield and wall reduces impact damage to the wall. A relationship between impact velocity and spall damage to the wall is demonstrated. Preliminary test results on Li-Al shield material indicate possible improved effectiveness over Al shields. C.D.

A88-31389*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
DEVELOPMENT AND PROPERTIES OF ALUMINUM-CLAD GRAPHITE/EPOXY TUBES FOR SPACE STRUCTURES
R. R. JOHNSON and M. H. KURAL (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 99-107. refs
(Contract NAS1-17660)
(AIAA PAPER 88-2472)

This paper presents the development and properties of seamless aluminum-clad P75/Epoxy tubes and the unique manufacturing method used in their production. Thermo-mechanical properties of the tubes were determined analytically and verified by tests. These properties were shown to be suitable for space structures that require high stiffness, low weight and thermal expansion, and dimensional stability during operational life. A special feature of the tubes is the ability to tune the tube for thermal expansion after fabrication by a chemical milling process. The tubes are also resistant to atomic oxygen and handling damage. The toughness of the tubes was demonstrated by impact testing. Cyclic thermal testing showed no adverse effects on the expansion and stiffness behavior of the tubes. The paper also includes a discussion of a joining method that uses aluminum end fittings and an efficient scarf joint configuration. Additional studies considered various adhesives and fitting materials. Joint allowables were higher for titanium and B4C particulate magnesium fittings. The effect of different adhesives under static loading conditions favored the high-strength adhesives. Author

A88-31391#
STRESS RUPTURE BEHAVIOR OF CARBON-FIBER METAL-LINED PRESSURE VESSELS FOR 30-YEAR OPERATION IN SPACE
HANK BABEL, DAVID HEMMERLING (McDonnell Douglas Astronautics Co., Saint Louis, MO), TONY PEARCE, and REX HADDOCK (Structural Composites Industries, Inc., Pomona, CA) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 117-120. refs
(AIAA PAPER 88-2479)

Initial results obtained in a 30-year program undertaken to evaluate high-strength carbon fibers for pressure vessels subjected to long-term sustained pressures with superimposed temperature and pressure cycles are reported. The stress-rupture behavior of several high-strength carbon fibers suitable for filament-winding pressure vessels was studied, using hydraulically loaded, approximately 4-in. diameter pressure vessels as test specimens. Future work planned in the program is described.
C.D.

A88-31392*# National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.
SPACE STATION - A FOCUS FOR THE DEVELOPMENT OF STRUCTURAL DYNAMICS SCALE MODEL TECHNOLOGY FOR LARGE FLEXIBLE SPACE STRUCTURES
ROBERT LETCHWORTH, PAUL E. MCGOWAN (NASA, Langley Research Center, Hampton, VA), and MARC J. GRONET (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 121-130. refs
(AIAA PAPER 88-2483)

The paper discusses the scale model technology being developed at the NASA Langley Research Center in support of the development of structural dynamic prediction methods for large flexible space structures. Space Station is used as a focus. The Dynamic Scale Model Technology (DSMT) Program is described, results of the effect of scaling Space Station components are presented, and supporting scale model technology development activities are described and results presented. The conceptual design of a hybrid-scale Pathfinder model for developing test techniques and suspension methods is also discussed, and a summary of the broad application of the scale model technology being developed is presented.
Author

A88-31395*# National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.
THE IMPACT OF ASYMMETRIC PHYSICAL PROPERTIES ON LARGE SPACE STRUCTURES
L. DERYDER (NASA, Langley Research Center, Hampton, VA), P. TROUTMAN, and M. HECK (Analytical Mechanics Associates, Inc., Hampton, VA) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 155-161.
(AIAA PAPER 88-2486)

The Space Station Reference Configuration is assembled in 19 assembly flights of several large structure elements of varied size and shape that contribute to its overall asymmetrical nature. The elements include thousands of square feet of solar arrays and thermal radiators, several hundred feet of truss structure, and several hundred thousand pounds of large-diameter cylindrical-shaped pressure modules housing scientific experiments and astronaut habitation areas. This paper quantitatively describes these physical characteristics of the fully assembled Space Station configuration. Several flight control design considerations are discussed relating to control system sizing, flight-path attitude orientation, payload pointing accommodation, and potential configuration modifications.
C.D.

A88-31397*# Boeing Co., Seattle, Wash.
SPACE STATION PRESSURE WALL REPAIR TECHNIQUES
MARTIN N. GIBBINS, PAUL H. STERN, and DONALD H. REID (Boeing Co., Seattle, WA) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 173-178.
(Contract NAS8-36426)
(AIAA PAPER 88-2488)

Space Station components are susceptible to hypervelocity impact damage from orbital debris and meteoroids. An especially vulnerable and critical space station component is the module pressure wall. Even with shielding, sufficiently large impacting particles can create penetrations ranging from pinholes to large jagged holes. This paper describes pressure wall damage repair patches along with procedures and tools for performing the repair. One patch incorporates an aluminum foil protected from the jagged hole edge with a Kevlar or foam pad. An adhesive holds the patch in place. Another patch uses a stiff plate held away from the damaged area by a low durometer rubber ring which also seals the plate edge. An adhesive will also secure this patch in place. Procedures were developed to prepare the punctured wall surface and apply the patch under weightless and unpressurized conditions. The procedures were tested in a laboratory and in the MSFC Neutral Buoyancy Simulator with models of the patches and tools.
Author

A88-31403
A COMPOSITE STRUCTURAL SYSTEM FOR A LARGE COLLAPSIBLE SPACE ANTENNA
L. HOLLAWAY and A. THORNE (Surrey, University, Guildford, England) IN: Composite structures 4; Proceedings of the Fourth International Conference, Paisley, Scotland, July 27-29, 1987. Volume 1. London and New York, Elsevier Applied Science, 1987, p. 1.30-1.44. Research sponsored by the Ministry of Defence. refs

An erectable reflector based on an extendable truss antenna is described which is deployed in earth orbit and then transported to geostationary orbit. A carbon fiber polyethersulfone material for building the reflector is suggested, and the manufacturing process is described. Compression and buckling tests on the mechanical properties of the composite after exposure to normal atmosphere and after degradation by temperature cycling in high vacuum are discussed. The temperature limits at present are found to be between +50 C and -95 C. The composite appears to be structurally satisfactory.
C.D.

A88-31427
RECENT ADVANCES IN DYNAMICS OF COMPOSITE STRUCTURES
CHARLES W. BERT (Oklahoma, University, Norman) IN: Composite structures 4; Proceedings of the Fourth International Conference, Paisley, Scotland, July 27-29, 1987. Volume 2. London and New York, Elsevier Applied Science, 1987, p. 2.1-2.17. refs

The present evaluation of the development status of composite structure dynamics gives attention to research completed since 1980. The fields addressed encompass the characterization of continuous and short fiber-reinforced composites' dynamic stiffness and damping, the vibratory response of composite beams, plates, and shells, low-velocity transverse impact effects in composite plates, and such dynamic instabilities as aeroelastic phenomena and nonlinear effects. The work reported ranges over experimental, analytical, and numerical investigations; suggestions for future research are presented.
O.C.

A88-31567#
A RECURSIVE POLE PLACEMENT METHOD FOR LARGE FLEXIBLE STRUCTURES
H. BARUH (Rutgers University, New Brunswick, NJ) IN: Vibration control and active vibration suppression; Proceedings of the Eleventh Biennial Conference on Mechanical Vibration and Noise, Boston, MA, Sept. 27-30, 1987. New York, American Society of Mechanical Engineers, 1987, p. 79-84. refs

This paper presents a recursive method to accomplish pole placement for control of large-order vibrating systems. The pole placement is based on matrix perturbation theory, where the controls are considered as a first-order perturbation on the uncontrolled system. The difference between the open-loop poles and the desired closed-loop poles is divided into regions small enough to maintain validity of the perturbation assumption. Control gains are then calculated in each region, resulting in a stepwise design. The method presented here is also applicable to any linear, time-invariant system. Author

A88-31570*# Purdue Univ., West Lafayette, Ind.
CONVERGENCE PROPERTIES OF MODAL COSTS FOR CERTAIN DISTRIBUTED PARAMETER SYSTEMS
A. HU and R. E. SKELTON (Purdue University, West Lafayette, IN) IN: Vibration control and active vibration suppression; Proceedings of the Eleventh Biennial Conference on Mechanical Vibration and Noise, Boston, MA, Sept. 27-30, 1987. New York, American Society of Mechanical Engineers, 1987, p. 107-114. refs
(Contract NAG1-642)

A complete modal cost analysis is presented for the vibration of various kinds of simple continua with different boundary conditions. Explicit formulas for the norm of the response (called the 'cost') are derived for these distributed parameter systems. The convergence theorems developed are useful in the model reduction of the equivalent continuum models of large space structures as well as in the selection of finite-element code for control design. Author

A88-31573
THE ROLE OF DAMPING IN VIBRATION AND NOISE CONTROL; PROCEEDINGS OF THE ELEVENTH BIENNIAL CONFERENCE ON MECHANICAL VIBRATION AND NOISE, BOSTON, MA, SEPT. 27-30, 1987
L. ROGERS, ED. (USAF, Wright-Patterson AFB, OH) and J. C. SIMONIS, ED. (Southwest Research Institute, San Antonio, TX) Conference sponsored by ASME. New York, American Society of Mechanical Engineers, 1987, 296 p. For individual items see A88-31574 to A88-31607.

The present conference on vibration- and noise-control damping considers the design and analysis of passively damped large space structures, optimization methods for viscoelastic damping treatment design, the modal coupling of structures with complex storage moduli, the effectiveness of impact dampers for space applications, adaptive damping for spacecraft by temperature control, the harmonic response of nonproportionately damped structures, and a novel method for representing damping material properties. Also discussed are very high damping in very large space structures, an integrated approach to friction damper design, experimental techniques for damping capacity measurements in metal-matrix composites, damping in unidirectional graphite/metal composites, and fractional derivatives in the description of damping material and phenomena. O.C.

A88-31580#
MODAL COUPLING OF STRUCTURES WITH COMPLEX STORAGE MODULI
S. TIWARI (Martin Marietta Corp., Denver, CO) IN: The role of damping in vibration and noise control; Proceedings of the Eleventh Biennial Conference on Mechanical Vibration and Noise, Boston, MA, Sept. 27-30, 1987. New York, American Society of Mechanical Engineers, 1987, p. 49-52. refs
(Contract F33615-82-C-3222)

A modal coupling technique of a large system with complex storage moduli is presented in this paper. The natural modes of vibration of each substructure are calculated by fixing the interface degrees of freedom of that substructure. The motion of each substructure is then written with reference to the constraint modes and fixed constraint complex modes. A global transformation is then used to incorporate the common boundary degrees of freedom of two or more substructures leaving the fixed constraint generalized dynamic coordinates of each substructure intact. The technique is verified with a planar truss structure having 40 degrees of freedom. Author

A88-31586#
LARGE SPACE STRUCTURE DAMPING TREATMENT PERFORMANCE - ANALYTIC AND TEST RESULTS
R. N. GEHLING (Martin Marietta Corp., Denver, CO) IN: The role of damping in vibration and noise control; Proceedings of the Eleventh Biennial Conference on Mechanical Vibration and Noise, Boston, MA, Sept. 27-30, 1987. New York, American Society of Mechanical Engineers, 1987, p. 93-100. refs
(Contract F33615-82-C-3222)

Future Large Space Structures (LSSs) will require some means of vibration damping in order to meet system performance goals. The necessary vibration suppression may be achieved through a passive or active means or through a combined passive/active control approach. The Representative System Article (RSA), developed under the Air Force/Martin Marietta Passive and Active Control of Space Structures program, was designed as a generic LSS for analytic study of passive and active control approaches. A laboratory model of the RSA, referred to as the Dynamic Test Article (DTA), is being fabricated to demonstrate the design methods and performance of passive damping treatments and mechanisms. This paper presents the analytic and experimental test results for three DTA components on which modal surveys have been conducted. The results demonstrate that passive damping can be successfully designed and predicted in LSS-type structures using the modal strain energy method and viscoelastic materials. Author

A88-31589#
FRACTIONAL DERIVATIVES IN THE DESCRIPTION OF DAMPING MATERIALS AND PHENOMENA
P. J. TORVIK and D. L. BAGLEY (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: The role of damping in vibration and noise control; Proceedings of the Eleventh Biennial Conference on Mechanical Vibration and Noise, Boston, MA, Sept. 27-30, 1987. New York, American Society of Mechanical Engineers, 1987, p. 125-135. refs

The use of constitutive equations which involve generalized or fractional derivatives for the description and prediction of the time dependent behavior of materials of interest for damping applications is described. Such relationships, which have origins in observed tendencies towards power law behavior rather than exponential response, are shown to be effective descriptors of the dynamic behavior of real materials. Such models are shown to have a sound theoretical basis and to satisfy essential thermodynamic relationships. When used in structural analysis they lead to causal, analytic results. Examples of the use of such relationships to predict vibratory and creep responses are given. The models and associated techniques are suggested as being highly appropriate for use in predicting the transient motion of large space structures. Author

A88-31594#
VERY HIGH DAMPING IN LARGE SPACE STRUCTURES
J. F. WILSON and L. P. DAVIS (Honeywell, Inc., Sperry Space Systems Div., Phoenix, AZ) IN: The role of damping in vibration and noise control; Proceedings of the Eleventh Biennial Conference on Mechanical Vibration and Noise, Boston, MA, Sept. 27-30, 1987. New York, American Society of Mechanical Engineers, 1987, p. 167-171.

Applications of passive damping to large space structures using viscous fluid damping elements are discussed. A heritage space qualified isolation system is described in which a similar damping element was used. A potential manifestation of this concept which could be used as the basic building block for large space trusses is described, and a design process for obtaining optimum dynamic performance is outlined. Numerical estimates of the performance achievable in a large Space Station-type truss predict dramatic reductions in settling times. Another manifestation suitable for providing local or supplemental damping is described, design

optimization techniques are discussed, and a proposed satellite application is presented. In this example a significant decrease in launch vibration loading without modifying the structural dynamics appears feasible. Author

A88-31587*# Auburn Univ., Ala.
AN INVESTIGATION OF THE DAMPING PHENOMENA IN WIRE ROPE ISOLATORS
M. A. CUTCHINS, J. E. COCHRAN, JR. (Auburn University, AL), S. GUEST (NASA, Marshall Space Flight Center, Huntsville, AL), N. G. FITZ-COY, and M. L. TINKER IN: The role of damping in vibration and noise control; Proceedings of the Eleventh Biennial Conference on Mechanical Vibration and Noise, Boston, MA, Sept. 27-30, 1987. New York, American Society of Mechanical Engineers, 1987, p. 197-204. refs
(Contract NAG8-532)

Early investigations into analytically modeling the dynamics of wire rope vibration isolators are described. Results from both very simple and very complex models are shown. The dynamic model which has the best agreement to date with simple one-dimensional experiments is one which includes a Coulomb friction force which varies with frequency. There are many yet unexplained phenomena, however. The fundamentals which underly multistrand NASTRAN models are given, and some early results are shown. An application simulation is briefly described, as is ongoing research. Author

A88-32176
STRUCTURES, STRUCTURAL DYNAMICS AND MATERIALS CONFERENCE, 29TH, WILLIAMSBURG, VA, APR. 18-20, 1988, TECHNICAL PAPERS. PARTS 1, 2, & 3
Conference sponsored by AIAA, ASME, ASCE, and AHS. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. Pt. 1, 619 p.; pt. 2, 504 p.; pt. 3, 673 p. For individual items see A88-32177 to A88-32363.

Among the topics discussed are structural tailoring and feedback control synthesis, passive vibration control in composites, the stability characteristics of deformable aircraft, the structural efficiency of graphite/epoxy aircraft ribs, force-management technology development, parameter identification of discrete time series models for transient response prediction, the chaotic motion of a shallow arch, the sonic fatigue of stiffened panels, composite rotor blade modeling, and the prevention of free-edge delamination. Also treated are the postbuckling behavior of composites, aeroelastic tailoring for wings, active cooling design for a scramjet engine, the control of energy dissipation in structures, the bending of sandwich beams, minimum-weight aircraft structures, finite element models for composite shells, a unitized composite fuselage fuel tank, oblique hypervelocity impact phenomena, and damage-dependent material damping in laminated composites. O.C.

A88-32177*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STRUCTURAL TAILORING AND FEEDBACK CONTROL SYNTHESIS - AN INTERDISCIPLINARY APPROACH
W. KEITH BELVIN (NASA, Langley Research Center, Hampton, VA) and K. C. PARK (Colorado, University, Boulder) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1-8. refs
(Contract F49620-87-C-0074)
(AIAA PAPER 88-2206)

Structural tailoring provides an attractive method to optimize the performance of actively controlled space structures. However, the simultaneous optimization of control gains and structural properties often becomes prohibitively expensive for large systems and physical insight is often lost in the resulting control law. This paper presents a method for optimization of the closed loop structural system using only structural tailoring. Optimal Linear Quadratic Regulator (LQR) control theory is used with weighting matrices chosen based on physical considerations. The LQR control law depends only on two scalar gains and the structural properties. Hence, the closed loop-performance can be expressed in terms of the structural parameters. Results are given for a beam and a truss-beam to show the simplicity of the method and the importance of structural tailoring to increase dynamic performance and to reduce the control effort. Author

A88-32193#
DYNAMIC CHARACTERIZATION OF STRUCTURES BY PULSE PROBING AND DECONVOLUTION
A. S. CARASSO and E. SIMIU (NBS, Gaithersburg, MD) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 147-157. Research supported by the U.S. Department of the Interior and USAF. refs
(AIAA PAPER 88-2230)

An account is given of the mathematical and computational basis of a procedure for the identification of linear structural systems from measurements of transient responses to specified pulses. The dynamic Green's functions fully characterize the dynamic behavior of such systems; these functions can be reconstructed by deconvolution from response measurements. The exponential growth of errors due to contamination of the response by noise is prevented by the regularization of the problem in order to minimize a Tikhonov functional. Attention is given to the properties of infinitely divisible pulses. O.C.

A88-32197*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A FINITE ELEMENT METHOD FOR TIME VARYING GEOMETRY IN MULTIBODY STRUCTURES
J. M. HOUSNER (NASA, Langley Research Center, Hampton, VA), S. C. WU, and C. W. CHANG (COMTEK Co., Grafton, VA) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 187-197. refs
(AIAA PAPER 88-2234)

A three-dimensional finite element formulation using convected coordinates is presented for the multibody dynamics of truss-like configurations. Unlike existing formulations, the present one does not superimpose nonlinear rigid body kinematics with linear structural mode shapes, an approach that has recently been shown to be grossly inaccurate under certain conditions. Instead, the finite element method is extended to treat large motions/deformations. The formulation is oriented toward joint dominated structures and places the generalized coordinates at the joints. For the planar spin-up of a flexible beam, results are compared with those derived from a commercially available computer program. The two programs predict nearly identical results. Author

A88-32225#
SOME THOUGHTS ON THE CONVERGENCE OF THE CLASSICAL RAYLEIGH-RITZ METHOD AND THE FINITE ELEMENT METHOD
LEONARD MEIROVITCH and MOON K. KWAK (Virginia Polytechnic Institute and State University, Blacksburg) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 449-458.
(Contract F33615-86-C-3233)
(AIAA PAPER 88-2269)

The Rayleigh-Ritz method is a technique for approximating the eigensolution associated with a distributed structure. The method amounts to approximating the solution of a differential eigenvalue problem that has no known closed-form solution by a finite series of admissible function, thus replacing the differential eigenvalue problem by an algebraic eigenvalue problem. The finite element method can be regarded as a Rayleigh-Ritz method, at least for structures. The main difference between the finite element method and the classical Rayleigh-Ritz method lies in the nature of the

admissible functions. An important question in both the classical Rayleigh-Ritz method and the finite element method is the speed of convergence. It is demonstrated in this paper that convergence of the classical Rayleigh-Ritz method can be vastly improved by introducing a new class of admissible functions, called quasi-comparison functions. Factors affecting the convergence of the finite element method are also discussed. Author

A88-32226*# Florida Univ., Gainesville.
LOW AUTHORITY-THRESHOLD CONTROL FOR LARGE FLEXIBLE STRUCTURES
D. C. ZIMMERMAN (Florida, University, Gainesville), D. J. INMAN (New York, State University, Buffalo), and J.-N. JUANG (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 459-469. refs
(Contract NGT-33-183-801; NSF MEA-83-51807; AF-AFOSR-85-0220)
(AIAA PAPER 88-2270)

An improved active control strategy for the vibration control of large flexible structures is presented. A minimum force, low authority-threshold controller is developed to bring a system with or without known external disturbances back into an 'allowable' state manifold over a finite time interval. The concept of a constrained, or allowable feedback form of the controller is introduced that reflects practical hardware implementation concerns. The robustness properties of the control strategy are then assessed. Finally, examples are presented which highlight the key points made within the paper. Author

A88-32228#
CONTROL FOR ENERGY DISSIPATION IN STRUCTURES
S. P. JOSHI, T. L. VINCENT (Arizona, University, Tucson), and Y. C. LIN IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 479-490. refs
(AIAA PAPER 88-2272)

Active vibration suppression of a large flexible space structure has been studied extensively in recent years. The studies include reduced-order modeling of structures with associated controller design. The main objectives of active control design are minimizing hardware and real-time computation while achieving efficient and robust control of the structure. Structure modeling and various control techniques are briefly discussed in this paper. Control designs based on state variable feedback are compared with an energy dissipation-based design. The effect of nonlinearities is considered by allowing saturation of the actuator control. The control design is experimentally implemented and compared with the numerical simulation. Critical issues related to experimental implementation are discussed. The energy dissipation control design is shown to be superior to others in light of the above-mentioned objectives. Author

A88-32229#
VIBRATION CONTROL OF TRUSS BEAM STRUCTURES USING AXIAL FORCE ACTUATORS
MICHIHIRO NATORI (Tokyo, University, Sagamihara, Japan), SHOICHI MOTOHASHI, KENICHI TAKAHARA, and FUMIHIRO KUWAO (Toshiba Corp., Kawasaki, Japan) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 491-499. refs
(AIAA PAPER 88-2273)

The vibration control of truss structures has attracted increasing attention due to their possible use in space applications such as Space Station structures. Since the members of truss structures are subjected to axial force, a concept of vibration control by the use of axial force actuators is expected to give a new feature on vibration control of truss structures compared with the conventional external force control. The effectiveness of the concept is demonstrated through the numerical simulation of simple two-dimensional truss beam, the model experiment of beam structure, and the corresponding simulation of experimental beam model. Author

A88-32240*# National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.
SOLUTION OF STRUCTURAL ANALYSIS PROBLEMS ON A PARALLEL COMPUTER
OLAF STORAASLI, EUGENE POOLE (NASA, Langley Research Center, Hampton, VA), JAMES ORTEGA, ANDREW CLEARY (Virginia, University, Charlottesville), and COURTENAY VAUGHAN IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 596-605. refs
(AIAA PAPER 88-2287)

The problems of a blade-stiffened panel with a hole subjected to compression, and a deployable space mast subjected to tip loads, are treated through the application of FEM to model generation followed by the solution of a linear system of equations. Direct and iterative approaches to the solution of the linear systems are solved in turn; for the panel problems using varying numbers of processors, the incomplete Cholesky-conjugate gradient method was the fastest iterative method on all but two instances in which the number of processors was large. O.C.

A88-32259*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DISPERSION, DAMPING AND CONFINEMENT OF PROPAGATING PULSES IN LARGE SPACE STRUCTURES
MICHAIL ZAK (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 825-836.
(Contract NAS7-918)
(AIAA PAPER 88-2311)

Pulse propagations in large space structures caused by repeated pulse excitations are studied analytically (by using the Z-transforms) and numerically. It is found that resonance regimes can be generated not only by periodical, but also by non-periodical repeated pulses; the conditions for such regimes are derived. Special attention is paid to the dispersion of propagating pulses due to structural irregularities, to damping of pulses due to appropriate combination of elastic and viscous properties of joints between structural members, and to the protection of certain areas of Large Space Structures (LSS) from impacts provided by a pulse trapping effect. Author

A88-32283#
OPTIMAL RECONFIGURATION OF THERMALLY DISTORTED WIRE MESH REFLECTORS FOR LARGE SPACE ANTENNAS
A. M. JANISZEWSKI (USAF, Aeronautical Laboratories, Wright-Patterson AFB, OH) and E. N. KUZNETSOV (Illinois, University, Urbana) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1041-1047. refs
(AIAA PAPER 88-2340)

The subject of this study is the structural implementation of a large parabolic space antenna in the form of a wire mesh. Being an underconstrained structural system, a wire mesh is inherently shapeless, with any particular geometirc configuration being a function of the applied load. This feature entails ultimate ease of control; geometric reconfiguration of the system can be purely kinematic (i.e., it does not have to involve elastic deformations). This work is an initial assessment of the kinematic reconfiguration of a thermally distorted wire mesh reflector, and of the efficiency of resulting reflector surfaces. Typical thermal patterns are applied, and the resulting changes in member lengths are calculated to serve as inputs to the procedure. The developed technique for optical kinematic reconfiguration employs mean-square distortion.

The primary goal of parametric studies performed was to evaluate the efficiency of reconfiguration in relation to the mesh fineness. The results look promising and confirm the viability of the concept of statically controlled geometry in underconstrained structural systems. Author

A88-32293*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MULTIPLE BOUNDARY CONDITION TEST (MBCT) - IDENTIFICATION WITH MODE SHAPES
C. P. KUO and B. K. WADA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1132-1142. refs
(AIAA PAPER 88-2353)

The multiple boundary condition test (MBCT) approach is a ground test method to test a class of large flexible structures which cannot be ground tested by state-of-the-art test methods due to the adverse terrestrial environment. The ultimate objective of a ground test is considered to be the validation and update of a mathematical model of the structure. The research to date has indicated the MBCT does work on numerical simulations and on experimental laboratory hardware. To date only the eigenvalue has been used in the model correlation/update by inclusion of the information in the nonlinear terms resulting from the difference between the analytical and measured eigenvectors. This paper presents the results of utilizing additional information, namely the difference in the analytical and the test eigenvectors, in the validation and update of the mathematical model. Author

A88-32294#
MODE SHAPE IDENTIFICATION AND ORTHOGONALIZATION
ALVAR M. KABE (Aerospace Corp., El Segundo, CA) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1143-1150. refs
(AIAA PAPER 88-2354)

An identification procedure to improve the mass weighted orthogonality of measured mode shapes is introduced. The procedure takes into account the degree of mode isolation present during measurement. This is accomplished by establishing a set of new mode shapes, from the measured vectors, that satisfy cross-orthogonality constraints and are a minimum deviation from the measured data. A significant feature is that each measured mode, from which improved modes are identified, can be established using different excitation locations and force levels. This allows the procedure to improve the isolation of modes measured with multishaker, sine dwell testing techniques. Author

A88-32296#
A GENERAL APPROACH TO MODAL ANALYSIS FOR TIME-VARYING SYSTEMS
A. M. BROWDER and R. M. ALEXANDER (Texas A & M University, College Station) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1162-1168. refs
(AIAA PAPER 88-2356)

Methods to generalize modal response analysis for the case of linear time-varying mechanical systems are developed and compared with regard to accuracy, reliability, and ease of implementation. Previous attempts to use modal methods for these systems have failed to include various terms due to time-variation in the eigenvectors; these terms are in fact negligible only under the very restrictive assumption that the system configuration varies quasi-statically. The methods developed here preserve all time-varying characteristics of the modal transformation, and therefore represent completely general approaches to the analysis of linear time-varying mechanical systems. Author

A88-32300#
STRUCTURAL MODEL VERIFICATION WITH LQO THEORY
HELENE LAPIERRE (Spar Aerospace, Ltd., Sainte-Anne-de-Bellevue, Canada) and GERMAIN OSTIGUY (Montreal, Universite, Canada) IN: Structures, Structural Dynamics and Material Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1194-1201. Sponsorship: Department of Supply and Services. refs
(Contract DSS-01ST-36100-6-4158)
(AIAA PAPER 88-2360)

A graphical tool is developed and validated for the verification and updating of large structure finite element models (FEM) for better correlation with modal test data. The elaborated Linear Quadratic Optimization (LQO) theory consists of a linearization and solution of the conventional matrix optimization problem which respects the connectivity of the structure and the symmetry of the stiffness matrix. The LQO theory is validated through a numerical and experimental sensitivity analysis. The results demonstrate the ability of the LQO algorithm to identify the regions of the structure and update the stiffness coefficients associated with the inappropriately modeled load paths. Author

A88-32301#
SYSTEM IDENTIFICATION OF FLEXIBLE STRUCTURES
K. Y. LEE (Pennsylvania State University, University Park), S. A. HOSSIAN (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA), and V. B. VENKAYYA (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1202-1209. refs
(AIAA PAPER 88-2361)

This paper presents a distributed parameter estimation scheme for flexible structures and investigates its computational merit for three generic problems. The distributed nature of the structure is retained throughout the development of the algorithm and a finite-element approximation is used only to implement the algorithm. This approach eliminates many problems associated with model truncation used in other methods of identification. The identification problem is formulated in infinite-dimensional spaces and an optimal control technique is used to minimize weighted least squares of error between the actual and the model data. Computer simulation studies are conducted using flexible beam models as examples. Numerical results show a close match between the estimated and true values of the parameters. Author

A88-32307# Alabama Univ., Huntsville.
ANALYSIS OF OBLIQUE HYPERVELOCITY IMPACT PHENOMENA
WILLIAM P. SCHONBERG (Alabama, University, Huntsville) and ROY A. TAYLOR (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1252-1261. refs
(AIAA PAPER 88-2370)

This paper describes the results of an experimental investigation of phenomena associated with the oblique hypervelocity impact of spherical projectiles on multisheet aluminum structures. A model that can be employed in the design of meteoroid and space debris protection systems for space structures is developed. The model consists of equations that relate crater and perforation damage of a multisheet structure to parameters such as projectile size, impact velocity, and trajectory obliquity. The equations are obtained through a regression analysis of oblique hypervelocity impact test data. This data shows that the response of a multisheet structure to oblique impact is significantly different from its response to normal hypervelocity impact. It was found that obliquely incident projectiles produce ricochet debris that can severely damage panels or instrumentation located on the exterior of a space structure.

Obliquity effects of high-speed impact must, therefore, be considered in the design of any structure exposed to a meteoroid or space debris environement. Author

A88-32323*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THREE PARALLEL COMPUTATION METHODS FOR STRUCTURAL VIBRATION ANALYSIS
OLAF STORAASLI, SUSAN BOSTIC (NASA, Langley Research Center, Hampton, VA), MERRELL PATRICK (Duke University, Durham, NC), UMESH MAHAJAN, and SHING MA IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1401-1410. refs
(AIAA PAPER 88-2391)

The Lanczos (1950), multisectioning, and subspace iteration sequential methods for vibration analysis presently used as bases for three parallel algorithms are noted, in the aftermath of three example problems, to maintain reasonable accuracy in the computation of vibration frequencies. Significant computation time reductions are obtained as the number of processors increases. An analysis is made of the performance of each method, in order to characterize relative strengths and weaknesses as well as to identify those parameters that most strongly affect computation efficiency. O.C.

A88-32325*# Carnegie-Mellon Univ., Pittsburgh, Pa.
TRANSIENT RESPONSE OF JOINT DOMINATED SPACE STRUCTURES - A NEW LINEARIZATION TECHNIQUE
G. A. FOELSCHE, J. H. GRIFFIN, and J. BIELAK (Carnegie-Mellon University, Pittsburgh, PA) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1423-1432. refs
(Contract NAG1-612)
(AIAA PAPER 88-2393)

The linearization method presented for calculating the transient responses of nonlinear systems due to initial disturbances is an extension of the 'describing function' approach, in which the system's steady-state response is calculated by representing such nonlinear elements as space structure joints with impedances that are functions of response amplitude. It is shown that, for the transient case, the steady-state impedances can be averaged over the range of responses in order to furnish equivalent values of stiffness and damping; these, for a given set of initial displacements, may be treated as constant during calculations of system response. O.C.

A88-32339*# Massachusetts Inst. of Tech., Cambridge.
EXPERIMENTAL COMPONENT MODE SYNTHESIS OF STRUCTURES WITH SLOPPY JOINTS
GARY H. BLACKWOOD and A. H. VON FLOTOW (MIT, Cambridge, MA) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1565-1575. refs
(Contract NAGW-21; AF-AFOSR-87-0031)
(AIAA PAPER 88-2411)

The accuracy of component mode synthesis is investigated experimentally for substructures coupled by nonideal joints. The work is based upon a segmented experimental beam for which free-interface frequency response matrices are measured for each segment. These measurements are used directly in component mode synthesis to predict the behavior of the assembled structure; the segments are then physically joined, and the resulting frequency response of the superstructure is compared to the prediction. Rotational freeplay is then introduced into the connecting joint, and the new superstructure frequency response is compared to the original linear component mode synthesis prediction. The level of accuracy to be expected in component mode synthesis is discussed in terms of the degree of nonlinearity in the joints, mode number, and mode shapes. Author

A88-32356#
TORTURING RECURSIVE PARAMETER IDENTIFICATION ALGORITHMS WITH A GAP NONLINEARITY
ANDREAS VON FLOTOW (MIT, Cambridge, MA) and SCOTT E. SCHAFFER IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1711-1718. refs
(AIAA PAPER 88-2439)

This paper examines the performance of the recursive least squares (RLS) algorithm and a derivative, the recursive lattice least squares (RLLS) algorithm in matching a linear model to a simple nonlinear model. The response of a single degree of freedom mass-spring-dashpot system to continuous forcing is simulated, and estimates for the modal parameters are obtained. Nonlinearity is introduced by allowing the restoring spring to slide without friction in a gap of specified width. Such a nonlinearity is of interest since it is a simple model of the effect of loose joints in a deployable spacecraft structure. The RLS algorithm is found to be the most reliable. Author

A88-32359#
MODEL ORDER REDUCTION TECHNIQUES IN LARGE SPACE STRUCTURE APPLICATIONS
HAGOP V. PANOSSIAN (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1733-1741. USAF-supported research. refs
(AIAA PAPER 88-2467)

The advantages and disadvantages of various techniques of model order reduction for large space structure applications are discussed. Condensation methods such as the Guyan (1965) reduction basically reduce the order of the original large dimensional linear model by discarding some of the modal deflections called 'slave' degrees-of-freedom and retaining the remaining 'master' degrees-of-freedom. Other techniques considered include aggregation methods, the cost decomposition method, the balanced state-space representation, and optimal projection methods. An approach for generating optimal reduced order models for large-scale systems based on an appropriate performance index is presented. R.R.

A88-32360*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PASSIVE DAMPING FOR SPACE TRUSS STRUCTURES
GUN-SHING CHEN and BEN K. WADA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1742-1749. refs
(AIAA PAPER 88-2469)

Theoretical and experimental studies of passive damping techniques in truss-type structures are presented, with emphasis on the use of viscoelastic damping in the parallel load path. The constraining member length is shown to be a convenient design variable for enhancing damping performance. Results are presented for integral damping members made of thin-wall aluminum tubes, concentric constraining members, and viscoelastic materials in a six-bay truss structure at low frequency and low dynamic strain conditions. Integral members with graphite/epoxy constraining members exhibited relatively low damping values due to the possible polymer interaction during the cocure stage. R.R.

A88-32718
SURVEY OF PARAMETER ESTIMATION METHODS IN EXPERIMENTAL MODAL ANALYSIS
U. FUELLEKRUG (DFVLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) (International Modal Analysis Conference, 5th, London, England, Apr. 1987) Society of

Environmental Engineers, Journal (ISSN 0374-356X), vol. 27-1, March 1988, p. 31-36, 44. refs

Parameter estimation methods using modal test data are reviewed. Existing techniques and methods are first classified in terms of the required measurement data. A distinction is made between modal and direct parameter identification methods, straightforward and iterative procedures, and local and global approaches. K.K.

N88-10070*# Boeing Aerospace Co., Seattle, Wash.
SPACE STATION INTEGRATED WALL DESIGN AND PENETRATION DAMAGE CONTROL
A. R. CORONADO, M. N. GIBBINS, M. A. WRIGHT, and P. H. STERN Jul. 1987 312 p
(Contract NAS8-36426)
(NASA-CR-179169; NAS 1.26:179169; D180-30550-4) Avail: NTIS HC A14/MF A01 CSCL 22B

The analysis code BUMPER executes a numerical solution to the problem of calculating the probability of no penetration (PNP) of a spacecraft subject to man-made orbital debris or meteoroid impact. The codes were developed on a DEC VAX 11/780 computer that uses the Virtual Memory System (VMS) operating system, which is written in FORTRAN 77 with no VAX extensions. To help illustrate the steps involved, a single sample analysis is performed. The example used is the space station reference configuration. The finite element model (FEM) of this configuration is relatively complex but demonstrates many BUMPER features. The computer tools and guidelines are described for constructing a FEM for the space station under consideration. The methods used to analyze the sensitivity of PNP to variations in design, are described. Ways are suggested for developing contour plots of the sensitivity study data. Additional BUMPER analysis examples are provided, including FEMs, command inputs, and data outputs. The mathematical theory used as the basis for the code is described, and illustrates the data flow within the analysis. B.G.

N88-10093*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STRUCTURES AND MATERIALS WORKING GROUP REPORT
ROBERT TORCZYNER (Lockheed Missiles and Space Co., Sunnyvale, Calif.) and BRANTLEY R. HANKS *In* NASA-Lewis Research Center, Spacecraft 2000 p 117-134 Jul. 1986
Avail: NTIS HC A11/MF A01 CSCL 22B

The appropriateness of the selection of four issues (advanced materials development, analysis/design methods, tests of large flexible structures, and structural concepts) was evaluated. A cross-check of the issues and their relationship to the technology drivers is presented. Although all of the issues addressed numerous drivers, the advanced materials development issue impacts six out of the seven drivers and is considered to be the most crucial. The advanced materials technology development and the advanced design/analysis methods development were determined to be enabling technologies with the testing issues and development of structural concepts considered to be of great importance, although not enabling technologies. In addition, and of more general interest and criticality, the need for a Government/Industry commitment which does not now exist, was established. This commitment would call for the establishment of the required infrastructure to facilitate the development of the capabilities highlighted through the availability of resources and testbed facilities, including a national testbed in space to be in place in ten years. B.G.

N88-10103*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
EFFICIENT PLACEMENT OF STRUCTURAL DYNAMICS SENSORS ON THE SPACE STATION
JANET A. LEPANTO and G. DUDLEY SHEPARD 29 Sep. 1987 25 p
(Contract NAS9-17560)
(NASA-CR-172015; NAS 1.26:172015; CSDL-R-2012; UPN-906)
Avail: NTIS HC A03/MF A01 CSCL 22B

System identification of the space station dynamic model will require flight data from a finite number of judiciously placed sensors on it. The placement of structural dynamics sensors on the space station is a particularly challenging problem because the station will not be deployed in a single mission. Given that the build-up sequence and the final configuration for the space station are currently undetermined, a procedure for sensor placement was developed using the assembly flights 1 to 7 of the rephased dual keel space station as an example. The procedure presented approaches the problem of placing the sensors from an engineering, as opposed to a mathematical, point of view. In addition to locating a finite number of sensors, the procedure addresses the issues of unobserved structural modes, dominant structural modes, and the trade-offs involved in sensor placement for space station. This procedure for sensor placement will be applied to revised, and potentially more detailed, finite element models of the space station configuration and assembly sequence. Author

N88-10121*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MECHANICAL PROPERTIES CHARACTERIZATION OF COMPOSITE SANDWICH MATERIALS INTENDED FOR SPACE ANTENNA APPLICATIONS
KENNETH J. BOWLES and RAYMOND D. VANNUCCI 1986 17 p Presented at Test Methods and Design Allowables for Fiber Composites: 2nd Symposium, Phoenix, Ariz., 3-4 Nov. 1986; sponsored by the American Society for Testing and Materials
(NASA-TM-88893; E-3310; NAS 1.15:88893) Avail: NTIS HC A03/MF A01 CSCL 11D

The composite materials proposed for use in the Advanced Communications Technology Satellite (ACTS) Program contains a new, high modulus graphite fiber as the reinforcement. A study was conducted to measure certain mechanical properties of the new fiber-reinforced material as well as of a composite-faced aluminum honeycomb sandwich structure. Properties were measured at -157, 22, and 121 C. Complete characterization of this material was not intended. Longitudinal tensile, picture-frame shear, short-beam shear, and flexural tests were performed on specimens of the composite face-sheet materials. Unidirectional, cross-plied, and quasi-isotropic fiber composite ply layup designs were fabricated and tested. These designs had been studied by using NASA's Integrated Composite Analyzer (ICAN) computer program. Flexural tests were conducted on (+/- 60/0 deg) sub s composite-faced sandwich structure material. Resistance strain gages were used to measure strains in the tensile, picture-frame, and sandwich flexural tests. The sandwich flexural strength was limited by the core strength at -157 and 22 C. The adhesive bond strength was the limiting factor at 121 C. Adhesive mechanical properties are reflected in sandwich structure flexural properties when the span-to-depth ratio is great enough to allow a significant shear effect on the load-deflection behavior of the sandwich beam. Most measured properties agreed satisfactorily with the properties predicted by ICAN. Author

N88-10340*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
ASSESSMENT OF THE COFS/MAST I PROJECT Final Report, period ended 15 Sep. 1987
MENG-SANG CHEW Sep. 1987 16 p
(Contract NAS1-17993)
(NASA-CR-181366; NAS 1.26:181366; TA-75) Avail: NTIS HC A03/MF A01 CSCL 13I

The COFS (MAST I) deployer/retractor assembly (DRA) which has a cluster of mechanisms that constitute the collapsible/extensible Mast, contains mechanisms/linkages that deploy and retract. The Mast is a flexible spatial (3D) linkage with hinges that lock into place during deployment to form a truss type structure. It is 60 meters long with repeating sections of two bays. Each bay has alternating diagonals. All joints are single degree-of-freedom hinges, arranged such that the Mast does not rotate during deployment/restow and that deformation energy is minimized. Mispan hinges are incorporated in the diagonals and half of the batten members. The various operational aspects and characteristics of the various mechanisms within the DRA are

analyzed. In view of the disadvantages of statical in determinancy as well as the inefficiencies inherent in recirculating gear trains, it is recommended that the bevel gear trains and the bell-crank mechanisms be redesigned. Author

N88-10387# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
A DMAP FOR UPDATING DYNAMIC MATHEMATICAL MODELS WITH MEASURED DATA
A. DEBOER and B. W. KOOI 11 Apr. 1986 25 p Presented at the MSC/NASTRAN European User's Conference, Munich, Fed. Republic of Germany
(Contract NIVR-1053)
(NLR-MP-86027-U; B8701064; ETN-87-90826) Avail: NTIS HC A03/MF A01

Two matrix correction methods are evaluated using a simple beam and a simple plate structure. Experimental data are obtained for the plate with an impact test and simulated in case of the beam. The structures were modelled with MSC/NASTRAN. To facilitate the comparison the Guyan reduction method was applied to calculate the natural frequencies and normal modes, and the position of the excitation points used in the tests coincide with the ASET. Both updating methods were programmed in DMAP. The results of the finite element calculation are obtained from the (old) problem tape and the experimental date are brought into the DMAP by bulk data cards. It is concluded that within MSC/NASTRAN the DMAP programming is a convenient facility to use for matrix correction methods. To guarantee the physical relevance of the updated matrices, the update methods have to be used with correlation methods. ESA

N88-10867*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
RECENT ADVANCES IN STRUCTURAL DYNAMICS OF LARGE SPACE STRUCTURES
LARRY D. PINSON Oct. 1987 23 p Presented at the 38th International Astronautical Federation Congress, Brighton, United Kingdom, 9-17 Oct. 1987
(NASA-TM-100513; NAS 1.15:100513) Avail: NTIS HC A03/MF A01 CSCL 22B

Recent progress in the area of structural dynamics of large space structures is reviewed. Topics include system identification, large angle slewing of flexible structures, definition of scaling limitations in structural models, and recent results on a tension-stabilized antenna concept known as the hoop-column. Increasingly complex laboratory experiments guide most of the activities leading to realistic technological developments. Theoretical progress in system identification based on system realization theory resulting in unification of several methods is reviewed. Experimental results from implementation of a theoretical large-angle slewing control approach are shown. Status and results of the development of a research computer program for analysis of the transient dynamics of large angle motion of flexible structures are presented. Correlation of results from analysis and vibration tests of the hoop-column antenna concepts are summarized. Author

N88-10868*# Massachusetts Inst. of Tech., Cambridge. Space Systems Lab.
STRUCTURAL ASSEMBLY DEMONSTRATION EXPERIMENT (SADE) Final Report
DAVID L. AKIN, RAYMOND A. MILLS, and MARY L. BOWDEN 20 Jul. 1987 148 p
(Contract NAS8-34959)
(NASA-CR-179205; NAS 1.26:179205; SSL-16-87) Avail: NTIS HC A07/MF A01 CSCL 22B

The purpose of the Structural Assembly Demonstration Experiment (SADE) was to create a near-term Shuttle flight experiment focusing on the deployment and erection of structural truss elements. The activities of the MIT Space Systems Laboratory consist of three major areas: preparing and conducting neutral buoyancy simulation test series; producing a formal SADE Experiment plan; and studying the structural dynamics issues of the truss structure. Each of these areas is summarized. B.G.

N88-10870*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE CONSTRUCTION
JANE A. HAGAMAN, ed. Oct. 1987 308 p Conference held in Hampton, Va., 6-7 Aug. 1986
(NASA-CP-2490; L-16378; NAS 1.55:2490) Avail: NTIS HC A14/MF A01 CSCL 22B

The purpose was to present to the aerospace community an in-depth review of Experimental Assembly of Structures on EVA (EASE)/Assembly Concept for Construction of Erectable Space Structures (ACCESS) space flight experiments and to present the status of activities regarding future space flight experiments and accompanying technology developments that will demonstrate the capability of on-orbit construction required for the Space Station.

N88-10872*# Massachusetts Inst. of Tech., Cambridge. Space Systems Lab.
EXPERIMENTAL ASSEMBLY OF STRUCTURES IN EVA: HARDWARE MORPHOLOGY AND DEVELOPMENT ISSUES
ROBERT S. WOLF and MARY L. BOWDEN *In* NASA. Langley Research Center, Hampton, Va. Space Construction p 13-30 Oct. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

A large body of data was obtained by MIT during neutral boyancy testing at Marshall Space Flight Center from 1980 to the present. These efforts, and the most significant results are summarized. The Experimental Assembly of Structure in EVA (EASE) flight experiment was undertaken to validate these results and flown on the STS 61-B in November 1985. The EASE experiment hardware is discussed and how the experiment goals dictate its size, shape, and operational characteristics, are illustrated. B.G.

N88-10873*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ACCESS FLIGHT HARDWARE DESIGN AND DEVELOPMENT
JOHN F. ROGERS and ROBIN D. TUTTEROW *In its* Space Construction p 31-53 Oct. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

Several items were found to be of immense value in the design and development of the Assembly Concept for Construction of Erectable Space Structures (ACCESS) hardware. The early availability of mock-up and engineering test hardware helped to develop the concept and prove the feasibility of the experiment. The extensive neutral buoyancy testing was invaluable in developing the procedures and timelines, proving that the hardware functioned as intended, and effectively trained the astronauts. The early involvement of the crew systems/astronaut personnel was extremely beneficial in shaping the design to meet the EVA compatibility requirements. Also, the early definition of coupled loads and on-orbit dynamic responses can not be overemphasized due to the relative uncertainty in the magnitude of these loads and their impact on the design. Author

N88-10874*# Teledyne Brown Engineering, Huntsville, Ala.
MISSION PECULIAR EQUIPMENT SUPPORT STRUCTURE: A PLATFORM FOR SPACE CONSTRUCTION
ROBERT HILL *In* NASA. Langley Research Center, Hampton, Va. Space Construction p 55-66 Oct. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

The Space Shuttle requires carriers to support payloads in the cargo bay. As a result, the Mission Peculiar Equipment Support Structure (MPESS) was designed to carry partial payloads aboard the shuttle. The efforts to customize the MPESS for the Experimental Assembly of Structure in EVA (EASE) and Assembly Concept for Construction of Erectable Space Structure (ACCESS) experiments are summarized. B.G.

N88-10875*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
MARSHALL SPACE FLIGHT CENTER'S ROLE IN EASE/ACCESS MISSION MANAGEMENT
GERALD W. HAWKINS *In* NASA. Langley Research Center, Hampton, Va. Space Construction p 67-80 Oct. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

The Marshall Space Flight Center (MSFC) Spacelab Payload Project Office was responsible for the mission management and development of several successful payloads. Two recent space construction experiments, the Experimental Assembly of Structures in Extravehicular Activity (EASE) and the Assembly Concept for Construction of Erectable Space Structures (ACCESS), were combined into a payload managed by the center. The Ease/ACCESS was flown aboard the Space Shuttle Mission 61-B. The EASE/ACCESS experiments were the first structures assembled in space, and the method used to manage this successful effort will be useful for future space construction missions. The MSFC mission management responsibilities for the EASE/ACCESS mission are addressed and how the lessons learned from the mission can be applied to future space construction projects are discussed. Author

N88-10876*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
A MONOGRAPH OF THE NATIONAL SPACE TRANSPORTATION SYSTEM OFFICE (NSTSO) INTEGRATION ACTIVITIES CONDUCTED AT THE NASA LYNDON B. JOHNSON SPACE CENTER FOR THE EASE/ACCESS PAYLOAD FLOWN ON STS 61-B
CHARLES CHASSAY *In* NASA. Langley Research Center, Hampton, Va. Space Construction p 81-96 Oct. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

The integration process of activities conducted at the NASA Lyndon B. Johnson Space Center (JSC) for the Experimental Assembly of Structures in Extravehicular activity (EASE)/Assembly Concept for Construction of Erectable Space Structures (ACCESS) payload is provided as a subset to the standard payload integration process used by the NASA Space Transportation System (STS) to fly payloads on the Space Shuttle. The EASE/ACCESS payload integration activities are chronologically reviewed beginning with the initiation of the flight manifesting and integration process. The development and documentation of the EASE/ACCESS integration requirements are also discussed along with the implementation of the mission integration activities and the engineering assessments supporting the flight integration process. In addition, the STS management support organizations, the payload safety process leading to the STS 61-B flight certification, and the overall EASE/ACCESS integration schedule are presented. Author

N88-10877*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
EASE/ACCESS GROUND PROCESSING AT KENNEDY SPACE CENTER
DEBORAH J. MOATES and ANA M. VILLAMIL *In* NASA. Langley Research Center, Hampton, Va. Space Construction p 97-131 Oct. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

The Kennedy Space Center (KSC) Payload Management and Operations Directorate is responsible for the processing of Space Shuttle payloads. The KSC responsibilities begin prior to hardware arrival at the launch site and extend until the experiments are returned to the investigators after the flight. The KSC involvement with the integration and checkout of payloads begins with participation in experiment, Mission Peculiar Equipment (MPE), and integrated payload design reviews. This involvement also includes participation in assembly and testing of flight hardware at the appropriate design center, university, or private corporation. Once the hardware arrives at the launch site, KSC personnel install the experiments and MPE onto a carrier in the Operations and Checkout (O & C) building. Following integration, the payload is functionally tested and then installed into the orbiter. After the mission, the payload is removed from the orbiter, deintegrated in the O & C building, and the experiments are turned over to the mission manager. One of the many payloads process at KSC consisted of two space construction experiments: the Experimental Assembly of Structures in Extravehicular Activity (EASE) and the Assembly Concept for Construction of Erectable Space Structures (ACCESS). The details of EASE/ACCESS integration, testing, and deintegration are addressed and how this mission can serve as a guide for future space construction payloads is discussed. Author

N88-10880*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
RESULTS OF THE ACCESS EXPERIMENT
WALTER L. HEARD, JR. and JUDITH J. WATSON *In its* Space Construction p 183-198 Oct. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

All basic EVA space construction tasks included in the experiment were accomplished on-orbit successfully, and the construction task time shows good correlation with neutral buoyancy data. However, the flight assembly times were slightly longer than the best times obtained in the water tank. This result was attributed by the EVA astronauts to the new, tighter tolerance truss hardware used on-orbit as opposed to the well-worn training hardware used in the neutral buoyancy and was, thus, not a space related phenomenon. The baseline experiment demonstrated that erectable structure can be assembled effectively by astronauts in EVA. The success of ACCESS confirmed the feasibility of EVA space assembly of erectable trusses and played a role in the decision to baseline the Space Station as a 5 meter erectable structure. Author

N88-12343*# Alabama Univ., Tuscaloosa. Dept. of Mathematics.
STOCHASTIC MODEL OF THE NASA/MSFC GROUND FACILITY FOR LARGE SPACE STRUCTURES WITH UNCERTAIN PARAMETERS: THE MAXIMUM ENTROPY APPROACH
WEI-SHEN HSIA 2 Dec. 1987 26 p
(Contract NAG8-081)
(NASA-CR-181489; NAS 1.26:181489) Avail: NTIS HC A03/MF A01 CSCL 12B

A stochastic control model of the NASA/MSFC Ground Facility for Large Space Structures (LSS) control verification through Maximum Entropy (ME) principle adopted in Hyland's method was presented. Using ORACLS, a computer program was implemented for this purpose. Four models were then tested and the results presented. B.G.

N88-13294# Brown Univ., Providence, R. I. Div. of Applied Mathematics.
COMPUTATIONAL METHODS FOR PROBLEMS IN AERODYNAMICS AND LARGE SPACE STRUCTURE USING PARALLEL AND VECTOR ARCHITECTURES Final Report
DAVID GOTTLIEB 1987 7 p
(Contract AF-AFOSR-85-0303; AF PROJ. 2304)
(AD-A185401; AFOSR-87-1189TR) Avail: NTIS HC A02/MF A01 CSCL 01C

One paper produced in this effort dealt with the importance of intermediate boundary conditions for approximate factorization schemes. A second paper derived stability results for spectral methods applied to initial-boundary value problems for hyperbolic systems. The paper demonstrates that one can bound certain weighted L2 spatial norms of the solution in terms of norms of the boundary data. A third paper deals with domain decomposition methods in the content of spectral techniques. Stability and convergence results are obtained for one and two dimensional cases. GRA

N88-13377# Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
MODELING AND CONTROL OF LARGE FLEXIBLE VEHICLES IN THE ATMOSPHERE AND SPACE Final Report, 15 Dec. 1981 - 14 Dec. 1986

HOLT ASHLEY 15 Jun. 1987 8 p
(Contract AF-AFOSR-82-0062; AF PROJ. 2302)
(AD-A185368; AFOSR-87-1171TR) Avail: NTIS HC A02/MF A01 CSCL 20K

Summary of major research findings in three topical areas: 1) traveling wave concepts in the dynamics and control of Large Space Structures, 2) passive damping in Large Space Structures Applications, and 3) active control of rigid and flexibe Manipulator Arms. The traveling wave concepts for characterizing the dynamics of flexible structures have introduced an alternative to modal synthesis and established a basis for the development of new controls algorithms. Passive damping studies identified various types of damping mechanisms including thermoelastic, and electromagnetic, and quantified their relative contributions. The active control studies generated a number of algorithms and control strategies and demonstration applications. GRA

N88-13388*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
POTENTIAL FOR ON-ORBIT MANUFACTURE OF LARGE SPACE STRUCTURES USING THE PULTRUSION PROCESS
MAYWOOD L. WILSON, IAN O. MACCONOCHIE, and GARY S. JOHNSON Dec. 1987 20 p Presented at the 46th Conference of Society of Allied Weight Engineers, Inc., Seattle, Wash., 18-20 May 1987
(NASA-TM-4016; L-16356; NAS 1.15:4016; SAWE-PAPER-1763)
Avail: NTIS HC A03/MF A01 CSCL 11D

On-orbit manufacture of lightweight, high-strength, advanced-composite structures using the pultrusion process is proposed. This process is adaptable to a zero-gravity environment by using preimpregnated graphite-fiber reinforcement systems. The reinforcement material is preimpregnated with a high-performance thermoplastic resin at a ground station, is coiled on spools for compact storage, and is transported into Earth orbit. A pultrusion machine is installed in the Shuttle cargo bay from which very long lengths of the desired structure is fabricated on-orbit. Potential structural profiles include rods, angles, channels, hat sections, tubes, honeycomb-cored panels, and T, H, and I beams. A potential pultrudable thermoplastic/graphite composite material is presented as a model for determining the effect on Earth-to-orbit package density of an on-orbit manufacture, the package density is increased by 132 percent, and payload volume requirement is decreased by 56.3 percent. The fabrication method has the potential for on-orbit manufacture of structural members for space platforms, large space antennas, and long tethers. Author

N88-13622*# Cincinnati Univ., Ohio. Dept. of Aerospace Engineering and Engineering Mechanics.
SIMULTANEOUS STRUCTURAL AND CONTROL OPTIMIZATION VIA LINEAR QUADRATIC REGULATOR EIGENSTRUCTURE ASSIGNMENT
G. A. BECUS, C. Y. LUI, V. B. VENKAYYA, and V. A. TISCHLER (Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.) *In* NASA-Marshall Space Flight Center, The 58th Shock and Vibration Symposium, Volume 1 p 225-232 Oct. 1987
Avail: NTIS HC A21/MF A01 CSCL 20K

A method for simultaneous structural and control design of large flexible space structures (LFSS) to reduce vibration generated by disturbances is presented. Desired natural frequencies and damping ratios for the closed loop system are achieved by using a combination of linear quadratic regulator (LQR) synthesis and numerical optimization techniques. The state and control weighing matrices (Q and R) are expressed in terms of structural parameters such as mass and stiffness. The design parameters are selected by numerical optimization so as to minimize the weight of the structure and to achieve the desired closed-loop eigenvalues. An illustrative example of the design of a two bar truss is presented. Author

N88-13622*# Honeywell, Inc., Glendale, Ariz.
VISCOUS DAMPED SPACE STRUCTURE FOR REDUCED JITTER
JAMES F. WILSON and L. PORTER DAVIS *In* NASA-Marshall Space Flight Center, The 58th Shock and Vibration Symposium, Volume 1 p 233-243 Oct. 1987
Avail: NTIS HC A21/MF A01 CSCL 20K

A technique to provide modal vibration damping in high performance space structures was developed which uses less than one once of incompressible fluid. Up to 50 percent damping can be achieved which can reduce the settling times of the lowest structural mode by as much as 50 to 1. This concept allows the designers to reduce the weight of the structure while improving its dynamic performance. Damping by this technique is purely viscous and has been shown by test to be linear over 5 orders of input magnitude. Amplitudes as low as 0.2 microinch were demonstrated. Damping in the system is independent of stiffness and relatively insensitive to temperature. Author

N88-13954*# Martin Marietta Corp., Denver, Colo. Astronautics Group.
FEASIBILITY STUDY FOR GAS-GRAIN SIMULATION FACILITY Final Contractor Report
J. B. MILLER and B. C. CLARK Sep. 1987 104 p
(Contract NAS2-11370)
(NASA-CR-177468; NAS 1.26:177468) Avail: NTIS HC A06/MF A01 CSCL 14B

Presented are the results of a feasibility study conducted to examine physical phenomena involved in gas-grain interactions using a Gas-Grain Simulation Facility (GGSF). Author

N88-14067*# Honeywell, Inc., Clearwater, Fla. Space and Strategic Avionics Div.
APPROACHES AND POSSIBLE IMPROVEMENTS IN THE AREA OF MULTIBODY DYNAMICS MODELING
K. W. LIPS and R. SINGH (DYNACS Engineering Co., Inc., Clearwater, Fla.) 30 Oct. 1987 45 p
(Contract NAS8-34588)
(NASA-CR-179227; NAS 1.26:179227) Avail: NTIS HC A03/MF A01 CSCL 01A

A wide ranging look is taken at issues involved in the dynamic modeling of complex, multibodied orbiting space systems. Capabilities and limitations of two major codes (DISCOS, TREETOPS) are assessed and possible extensions to the CONTOPS software are outlined. In addition, recommendations are made concerning the direction future development should take in order to achieve higher fidelity, more computationally efficient multibody software solutions. Author

N88-14115*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONTINUUM MODELING OF LARGE LATTICE STRUCTURES: STATUS AND PROJECTIONS
AHMED K. NOOR and MARTIN M. MIKULAS, JR. Feb. 1988 79 p
(NASA-TP-2767; L-16360; NAS 1.60:2767) Avail: NTIS HC A05/MF A01 CSCL 22B

The status and some recent developments of continuum modeling for large repetitive lattice structures are summarized. Discussion focuses on a number of aspects including definition of an effective substitute continuum; characterization of the continuum model; and the different approaches for generating the properties of the continuum, namely, the constitutive matrix, the matrix of mass densities, and the matrix of thermal coefficients. Also, a simple approach is presented for generating the continuum properties. The approach can be used to generate analytic and/or numerical values of the continuum properties. Author

N88-14121# Rensselaer Polytechnic Inst., Troy, N.Y.
STUDIES OF THE STRUCTURAL DYNAMIC BEHAVIOR OF SATELLITE ANTENNA SYSTEM Final Report, 1 Sep. 1983 - 29 Jun. 1987
ROBERT G. LOEWY 29 Jun. 1987 28 p
(Contract AF-AFOSR-0348-83)
(AD-A185526; AFOSR-87-1167TR) Avail: NTIS HC A03/MF A01 CSCL 22B

A Transfer Matrix (TM) Analysis is formulated to predict the

natural modes and frequencies of hoop-maypole type satellite antenna systems. Two directions of bending, axial extension/compression and torsion are represented as coupled by feed assemblies canted with respect to the mast, solar panels tilted out of the plane of the center structure and masses offset from the mast centerline. Shear deflections, large steady cable loads and large compressive loads are accounted for in appropriate members. Using properties chosen as representative of such structures, trends are predicted with variations in size and configuration for several simplified configurations; these include, (a) two-dimensional cable-suspended rigid bars on a flexible center body (mast), (b) T and H -shaped center body sub structures in two and three-dimensional vibrations and (c) cable-stiffened, planar polygonal hoop assemblies. In the last of these cyclic symmetry had to be invoked to avoid numerical difficulties. Some general conclusions are drawn regarding the free vibrations of such structures. The TM approach is seen as a viable alternative to FEM analyses, when structures are encountered which have major substructures with one dimension longer than its others. Full use of the TM analysis for hoop-maypole type structures must await a reformulation in which cyclic symmetry can be invoked, as in the plane hoop cases. GRA

N88-15000# Army Construction Engineering Research Lab., Champaign, Ill.
INVESTIGATION OF DESIGN CONCEPTS FOR LARGE SPACE STRUCTURES TO SUPPORT MILITARY APPLICATIONS Final Report
R. A. EUBANKS and ALVIN SMITH Sep. 1987 34 p
(AD-A186098; CERL-TR-M-87/16) Avail: NTIS HC A03/MF A01 CSCL 22B

Future exploration and enterprise in low-Earth orbit will most likely require space stations for support. In addition, promotion of the Strategic Defense Initiative is mandating research and development into technologies for building structures to serve military objectives in space. However, an assessment of the state of the art for space construction technology has revealed that the field is immature, with little conceptual and experimental research completed. The U.S. Army Construction Engineering Research Laboratory (USA-CERL) has collected information on existing technologies for possible application in designing large space structures (LSS) for military support. This work is part of an effort to ensure mission-responsiveness in anticipation of a role in space construction. Military structures will require design criteria much different from those of experimental space stations. Proposed conceptual criteria for both types of structures are compared and differences are noted. Much R and D is needed before any of these structures can be developed in space. To serve as background for future studies, a literature critique is included in this report. GRA

N88-15001# WEA, Cambridge, Mass.
NATURAL FREQUENCIES AND STRUCTURAL INTEGRITY ASSESSMENT OF LARGE SPACE STRUCTURES Technical Report, 1 Sep. 1985 - 1 Apr. 1987
JAMES H. WILLIAMS, JR. and RAYMOND J. NAGEM 1 Apr. 1987 39 p
(Contract F49620-85-C-0148)
(AD-A186139; AFOSR-87-1290TR) Avail: NTIS HC A03/MF A01 CSCL 20K

In a previous report, transfer matrices and joint coupling matrices are used to compute natural frequencies of vibration of a five-bay planar lattice structure. In this report, the problem of detecting damage in the five-bay planar lattice structure is considered. Seven different states of damage are assumed. Each damage state corresponds to a disconnected or partially disconnected joint in the lattice. Transfer matrices and joint coupling matrices are used to compute natural frequencies associated with each damage state. The natural frequencies computed for each damage state are significantly different from the natural frequencies of the undamaged lattice; for example, the frequencies of the first flexible mode of the damaged lattice are 26 to 83 percent lower than the frequency of the first flexible node of the undamaged lattice. The results presented here demonstrate that measurement of natural frequencies is a potentially useful method for detecting damage in lattice structures, at least, for the types of damage considered here. However, it is also shown here that measurement of natural frequencies alone is not sufficient, in general, to determine the location of damage within the lattice structure. Thus, measurement of natural frequencies should be regarded as only a part of a complete nondestructive evaluation method. After the results obtained here are presented, some suggestions for NDE methods which may be capable of providing more quantitative measures of structural integrity. GRA

N88-15002# WEA, Cambridge, Mass.
WAVE PROPAGATION EXPERIMENTS ON 22-BAY LATTICE Technical Report, 1 Sep. 1985 - 1 Jun. 1987
JAMES H. WILLIAMS, JR. and JIA J. ZHANG 1 Jun. 1987 37 p
(Contract F49620-85-C-0148)
(AD-A186140; AFOSR-87-1289TR) Avail: NTIS HC A03/MF A01 CSCL 22B

Wave propagation characteristics of large space structures (LSS) affect their performance, integrity and the ability to nondestructively assess their integrity. In this study, wave propagation characteristics of an aluminum 22-bay planar lattice structure are determined experimentally. Two ultrasonic piezoceramic longitudinal transducers are mounted at various locations on the structure. Wave measurements are obtained by injecting an impulsive load via the transmitting transducer and recording the response via the receiving transducer. The waves injected into the structure are longitudinal waves, transverse to the surface, although a complex stress distribution which may be described by directivity functions is actually realized. The impulsive loading signal has a broad frequency spectrum containing frequencies greater than 0.5MHz. GRA

N88-15003# Harris Corp., Melbourne, Fla. Government Aerospace Systems Div.
MAXIMUM ENTROPY/OPTIMAL PROJECTION DESIGN SYNTHESIS FOR DECENTRALIZED CONTROL OF LARGE SPACE STRUCTURES Annual Report, Oct. 1986 - Apr. 1987
DAVID C. HYLAND and DENNIS S. BERNSTEIN May 1987 233 p
(Contract F49620-86-C-0038)
(AD-A186359; AFOSR-87-1196TR) Avail: NTIS HC A11/MF A01 CSCL 22A

The Maximum Entropy/Optical Projection (MEOP) methodology is a novel approach to designing implementable vibration-suppression controllers for large space systems. Two issues, in particular, have been addressed, namely, controller order (i.e. complexity) and systems robustness (i.e., insensitivity to plant variations). Extensions developed herein include generalizations to decentralized controller architectures and a new robustness analysis technique known as Majorant Robustness Analysis. GRA

N88-15830*# Howard Univ., Washington, D. C. Dept. of Mechanical Engineering.
THE DYNAMICS AND CONTROL OF LARGE-FLEXIBLE SPACE STRUCTURES, PART 10 Final Report
PETER M. BAINUM and A. S. S. R. REDDY Jan. 1988 199 p
(Contract NSG-1414)
(NASA-CR-182426; NAS 1.26:182426) Avail: NTIS HC A09/MF A01 CSCL 22B

A mathematical model is developed to predict the dynamics of the proposed orbiting Spacecraft Control Laboratory Experiment (SCOLE) during the station keeping phase. The equations of motion are derived using a Newton-Euler formulation. The model includes the effects of gravity, flexibility, and orbital dynamics. The control is assumed to be provided to the system through the Shuttle's three torquers, and through six actuators located by pairs at two points on the mast and at the mass center of the reflector. The modal shape functions are derived using the fourth order beam equation. The generic mode equations are derived to account for

the effects of the control forces on the modal shape and frequencies. The equations are linearized about a nominal equilibrium position. The linear regulator theory is used to derive control laws for both the linear model of the rigidized SCOLE as well as that of the actual SCOLE including the first four flexible modes. The control strategy previously derived for the linear model of the rigidized SCOLE is applied to the nonlinear model of the same configuration of the system and preliminary single axis slewing maneuvers conducted. The results obtained confirm the applicability of the intuitive and appealing two-stage control strategy which would slew the SCOLE system, as if rigid to its desired position and then concentrate on damping out the residual flexible motions. Author

N88-16792* Rockwell International Corp., Downey, Calif. Space Station Systems Div.
SPACE STATION STRUCTURES DEVELOPMENT
V. B. TELLER Oct. 1986 332 p
(Contract NAS8-36421)
(NASA-CR-179261; NAS 1.26:179261; SSS-86-0133) Avail: NTIS HC A15 CSCL 22B

A study of three interrelated tasks focusing on deployable Space Station truss structures is discussed. Task 1, the development of an alternate deployment system for linear truss, resulted in the preliminary design of an in-space reloadable linear motor deployer. Task 2, advanced composites deployable truss development, resulted in the testing and evaluation of composite materials for struts used in a deployable linear truss. Task 3, assembly of structures in space/erectable structures, resulted in the preliminary design of Space Station pressurized module support structures. An independent, redundant support system was developed for the common United States modules. Author

N88-16812*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
EMULATING A FLEXIBLE SPACE STRUCTURE: MODELING
H. B. WAITES, S. C. RICE, and V. L. JONES (Control Dynamics Co., Huntsville, Ala.) Feb. 1988 22 p
(NASA-TM-100320; NAS 1.15:100320) Avail: NTIS HC A03/MF A01 CSCL 22B

Control Dynamics, in conjunction with Marshall Space Flight Center, has participated in the modeling and testing of Flexible Space Structures. Through the series of configurations tested and the many techniques used for collecting, analyzing, and modeling the data, many valuable insights have been gained and important lessons learned. This paper discusses the background of the Large Space Structure program, Control Dynamics' involvement in testing and modeling of the configurations (especially the Active Control Technique Evaluation for Spacecraft (ACES) configuration), the results from these two processes, and insights gained from this work. Author

N88-17683 Virginia Polytechnic Inst. and State Univ., Blacksburg.
SENSITIVITY OF ACTIVE VIBRATION CONTROL TO STRUCTURAL CHANGES AND MODEL REDUCTION Ph.D. Thesis
ZORAN NAUM MARTINOVIC 1987 123 p
Avail: Univ. Microfilms Order No. DA8721990

The analytical study presented is concerned with two types of sensitivity of active vibration control of large space structures (LSS). The first one required for assessing robustness, is the sensitivity of the performance and stability of the control system to changes in structure and to model reduction. The second type is the sensitivity of the optimum design of the control system to changes in the structure. This sensitivity is of interest in assessing the need for integrated structure/control design. Three direct rate feedback control techniques are studied for a laboratory structure which has characteristics of LSS and then compared to standard linear quadratic control. The baseline design of each control system is obtained first and then sensitivity analysis conducted. Dissert. Abstr.

N88-17688*# Boeing Aerospace Co., Seattle, Wash.
SPACE STATION INTEGRATED WALL DAMAGE AND PENETRATION DAMAGE CONTROL. TASK 5: SPACE DEBRIS MEASUREMENT, MAPPING AND CHARACTERIZATION SYSTEM Final Report, 1 Aug. - 16 Dec. 1987
B. M. LEMPRIERE 16 Dec. 1987 107 p
(Contract NAS8-36426)
(NASA-CR-179281; NAS 1.26:179281; D180-30706-1) Avail: NTIS HC A06/MF A01 CSCL 22A

The procedures and results of a study of a conceptual system for measuring the debris environment on the space station is discussed. The study was conducted in two phases: the first consisted of experiments aimed at evaluating location of impact through panel response data collected from acoustic emission sensors; the second analyzed the available statistical description of the environment to determine the probability of the measurement system producing useful data, and analyzed the results of the previous tests to evaluate the accuracy of location and the feasibility of extracting impactor characteristics from the panel response. The conclusions were that for one panel the system would not be exposed to any event, but that the entire Logistics Module would provide a modest amount of data. The use of sensors with higher sensitivity than those used in the tests could be advantageous. The impact location could be found with sufficient accuracy from panel response data. The waveforms of the response were shown to contain information on the impact characteristics, but the data set did not span a sufficient range of the variables necessary to evaluate the feasibility of extracting the information. Author

N88-17730# National Aerospace Lab., Tokyo (Japan).
FORMULATION METHODS OF RIGID MULTIBODY SYSTEMS FOR LARGE SPACE STRUCTURES AND SOME RESULTS OF COMPUTER SIMULATION
YOSHIAKI OHKAMI, OSAMU OKAMOTO, TAKASHI KIDA, ISAO YAMAGUCHI, KATSUHIKO YAMADA, and KAZUO TSUCHIYA Aug. 1987 19 p In JAPANESE; ENGLISH summary
(NAL-TR-942; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

A comparative study of the simulation algorithms for dynamics of large space structures modeled as a collection of rigid multibodies connected by hinges is described. Two algorithms have been independently developed at two research institutes. One method is based upon the well-known Euler Newton formulation and the unified matrix approach. The unified matrix approach solves the dynamical equation for the derivatives of the non-holonomic velocities and the internal torques and forces simultaneously, hence permitting us to deal with an arbitrary large space structure (LSS) configuration. The other method provides for an efficient and fast algorithm based on Kane's method with modification in the inertia dyadic and other quantities. Both methods have been applied to two typical examples: the first is a satellite with four-link manipulator as a model of a chain structure, and the second is a satellite with a closed loop deployment mechanism. The results coincide satisfactorily and the validity of the two methods has been proven perfectly. The numerical values given in this report will be useful as a reference in other simulations. Author

N88-18009# Colorado Univ., Boulder. Dept. of Electrical and Computer Engineering.
ROBUST CONTROLLER DESIGN FOR FLEXIBLE STRUCTURES
RENJENG SU and NASSIM M. ARBOUZ 1987 13 p
(Contract AF-AFOSR-0198-86)
(AD-A187217; AFOSR-87-1561TR) Avail: NTIS HC A03/MF A01 CSCL 20K

This document considers the problem of control of a beam which is moving in the x-y plane. It extends from x=0 to x=L. The left end at x=0 is clamped to an actuator which moves the beam along the y-axis. The control input is the force u(t) in y direction. While moving, the beam may vibrate. Let z(t) denote the displacement of the left from y=0, and w(t,x), the displacement of the beam from the line y=z(t) at position x and time t. Suppose a position sensor is placed on the beam and the sensing output is v(t, sub 0) = z(t) + w(t,x0), where 0 less than x sub 0 less than

L is the sensor location. We are interested in the case when the flexure w(t,x) of the beam is significant. The problem is to synthesize a feedback control law which moves the beam from one position to another in a stable manner. It is well known that when the sensor and the actuator are colocated a simple lead compensator suffices to produce a stable design. This result holds even when the beam dynamics are considered as a system with infinite zero-damping modes, and can be shown using root locus argument. This stabilization method may break down, however, when there is a positional gap between the sensor and actuator. In this case the classical compensation techniques are no longer effective. Time-domain optimization approaches based on state-space models have been applied to this problem. This article presents a case study of noncolocated beam control problem using frequency-domain optimization method proposed by Professor Kwakernaak. GRA

N88-18750# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
DEVELOPMENT OF THE EXTENDABLE AND RETRACTABLE MAST (ERM), DESIGN PHASE 2. VOLUME 1 Final Report
SPECHT, SCHMID, CHELLINGSWORTH, WISLEZ, BHATTI, and STENNE (Societe Anonyme Belge de Constructions Aeronautiques, Brussels, Belgium) Paris, France ESA 6 Mar. 1987 292 p Original contains color illustrations
(Contract ESTEC-5676/83-NL-AN(SC))
(RP-2010-0000-DS/09; ESA-CR(P)-2481; ETN-88-91697) Avail: NTIS HC A13/MF A01

An Extendable and Retractable Mast (ERM) for space applications such as deployment and retraction of high power rollable, foldable, or rigid solar arrays, large unfurlable antennas, and scientific payloads, was developed. The coverage of a large field of application requires a strong and stiff light-weight mast with good pointing accuracy allowing the adaptation of heavy tip masses as well as the fixation of line-loads to intermediate attachment points along the mast at the same time. The ERM payload capability is 40 kg on tip, plus 10 kg/m line load, plus 100N eccentric load. Deployed length is 40 m. The ERM is designed as a spindle-driven telescopic mast in carbon-fiber reinforced plastics (CFRP) technology. A 40 m solar array mast and a 20 m antenna mast were considered. The feasibility of a 60 m mast is also shown. Manufacturing and test of a breadboard model hardware, and the detailed design of an engineering model mast are described. ESA

N88-18941*# Martin Marietta Aerospace, Denver, Colo.
THE INTEGRATION OF A MESH REFLECTOR TO A 15-FOOT BOX TRUSS STRUCTURE. TASK 3: BOX TRUSS ANALYSIS AND TECHNOLOGY DEVELOPMENT Final Report, Apr. 1985 - Nov. 1986
E. E. BACHTELL, W. F. THIEMET, and G. MOROSOW Mar. 1987 75 p
(Contract NAS1-17551)
(NASA-CR-178228; NAS 1.26:178228; MCR-86-669-TASK-3)
Avail: NTIS HC A04/MF A01 CSCL 20K

To demonstrate the design and integration of a reflective mesh surface to a deployable truss structure, a mesh reflector was installed on a 15 foot box truss cube. The specific features demonstrated include: (1) sewing seams in reflective mesh; (2) mesh stretching to desired preload; (3) installation of surface tie cords; (4) installation of reflective surface on truss; (5) setting of reflective surface; (6) verification of surface shape/accuracy; (7) storage and deployment; (8) repeatability of reflector surface; and (9) comparison of surface with predicted shape using analytical methods developed under a previous task. Author

N88-19483# Army Construction Engineering Research Lab., Champaign, Ill.
STATE-OF-THE-ART TECHNOLOGIES FOR CONSTRUCTION IN SPACE: A REVIEW Final Report
CHARLES C. LOZAR and L. D. STEPHENSON Sep. 1987 88 p
(Contract MIPR-W31RPD-7-D4099; DA PROJ. 4A1-62731-AT-41)
(AD-A188412; CERL-TR-M-87/17) Avail: NTIS HC A05/MF A01 CSCL 22B

Future exploration and enterprise in low-Earth orbit will most likely require space stations for support. In addition, promotion of the Strategic Defense Initiative (SDI) is mandating research and development (R and D) into technologies for building structures to serve military objectives in space. However, an assessment of the state of the art for space construction technology has revealed that the field is immature, with little conceptual and experimental research completed. The U.S. Army Construction Engineering Research Laboratory (USA-CERL) has collected information on existing technologies for possible application in designing large space structures (LSS) for military support. This work is part of an effort by the U.S. Army Corps of Engineers (USACE) to ensure mission-responsiveness in anticipation of a role in space construction. USA-CERL is USACE's designated lead laboratory for this program. Military structures will require design criteria much different from those of experimental space stations. Proposed conceptual criteria for both types structures are compared and differences are noted. Much R and D is needed before any of these structures can be deployed in space. GRA

N88-19548*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PRELIMINARY INVESTIGATION OF STABILITY OF A FIN-STIFFENED SLENDER STRUT
MARK S. LAKE and K. CHAUNCEY WU Apr. 1988 24 p
(NASA-TM-4034; L-16411; NAS 1.15:4034) Avail: NTIS HC A03/MF A01 CSCL 22B

A fin-stiffened strut concept which possesses high bending stiffness and low packaged volume has been identified for use on large space structures. The concept incorporates three curved fins which deploy from a core tube to increase the effective cross-sectional moment of inertia, the buckling load, and the vibration frequency of the strut. A strut design incorporating welded fin connections provides an upper bound of the strut buckling load. A strut design which allows the individual fins and core to move independently in the strut axial direction provides a lower bound of the strut buckling load which is approximately 20 to 25 percent of the upper bound. A practical strut design, incorporating hinge assemblies which constrain the fins to move together but independently of the core tube in the strut axial direction, provides a buckling load which is 75 to 80 percent of the upper bound. Euler's equation can be used to accurately predict buckling loads for the bounding designs. Flat plate finite element models of all designs give results that agree to within 10 percent of the experimental values. Equivalent beam models of the strut give results which are slightly less accurate. Author

N88-19585*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
COST EFFECTIVE DEVELOPMENT OF A NATIONAL TEST BED
H. B. WAITES, V. L. JONES, and S. M. SELTZER (Control Dynamics Co., Huntsville, Ala.) Feb. 1988 18 p
(NASA-TM-100321; NAS 1.15:100321) Avail: NTIS HC A03/MF A01 CSCL 22B

For several years, the Marshall Space Flight Center has pursued the coordinated development of a Large Space Structures (LSS) National Test Bed for the investigation of numerous technical issues involved in the use of LSS in space. The origins of this development, the current status of the various test facilities and the plans laid down for the next five years' activities are described. Particular emphasis on the control and structural interaction issues has been paid so far; however, immediately emerging are user applications (such as the proposed pinhole occulter facility). In the immediate future, such emerging technologies as smart robots and multibody interactions will be studied. These areas are covered. Author

N88-19592*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MAST MATERIAL TEST PROGRAM (MAMATEP)

MICHAEL L. CIANCONE and SHARON K. RUTLEDGE 1988 13 p Presented at Issues of the International Space Station, Williamsburg, Va., 21-22 Apr. 1988; sponsored by AIAA
(NASA-TM-100821; E-4005; NAS 1.15:100821; AIAA-88-2475)
Avail: NTIS HC A03/MF A01 CSCL 11D

The Mast Material Test Program (MAMATEP) at NASA Lewis is discussed. Objectives include verifying the need for, and evaluating the performance of, various protection techniques for the Solar Array Assembly mast of the Space Station Photovoltaic Power Module. Mast material samples were evaluated in terms of mass and bending modulus, measured before and after environmental exposure. Test environments included atomic oxygen exposure (RF plasma asher), thermal cycling, and mechanical flexing. Protective coatings included CV-1144 silicon, a Ni/Au/InSn eutectic, and an open weave, Al braid. Results indicate that unprotected samples degrade in an atomic oxygen environment at a steady rate. Open weave, Al braid offers little protection for the fiberglass-epoxy sample in an asher environment. Ni/Au/InSn eutectic offers excellent protection in an asher environment prior to thermal cycling and mechanical flexing. Long duration asher results from unprotected samples indicate that, even though the fiberglass-epoxy degrades, a protection technique may not be necessary to ensure structural integrity. However, a protection technique may be desirable to limit or contain the amount of debris generated by the degradation of the fiberglass-epoxy.
Author

N88-20235*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
WORKSHOP ON TECHNOLOGY DEVELOPMENT ISSUES FOR THE LARGE DEPLOYABLE REFLECTOR (LDR)
KENJI NISHIOKA, ed. Feb. 1988 118 p Workshop held in Asilomar, Calif., 17-22 Mar. 1985
(NASA-CP-2407; A-85394; NAS 1.55:2407) Avail: NTIS HC A06/MF A01 CSCL 03B

The results of the 2nd Large Deployable Reflector (LDR) Technology Review Workshop held at Asilomar, California, March 17 to 22, 1985, are summarized. The workshop was convened to update LDR Technology status and to revise as necessary the results for the first LDR Workshop held in June 1982. There were some 100 participants representing government agencies, industry, and universities. This Workshop's goal was to assess, identify, and set priorities for the LDR technology issues based on requirements identified in the first workshop. Four high-priority technology areas were identified: (1) mirror materials and construction; (2) sensing and controls; (3) system-simulation and modeling capability; and (4) submillimeter instruments. The results of the workshop were used to provide a list of technology issues for the development of a technology initiatives plan for the LDR by NASA's Office of Aeronautics and Space Technology. Author

04

THERMAL CONTROL

Includes descriptions of analytical techniques, passive and active thermal control techniques, external and internal thermal experiments and analyses and trade studies of thermal requirements.

A88-11734*# Mercer Univ., Macon, Ga.
SELF-SHADOWING EFFECTS ON THE THERMAL-STRUCTURAL RESPONSE OF ORBITING TRUSSES
JACK MAHANEY (Mercer University, Macon, GA) and EARL A. THORNTON (Old Dominion University, Norfolk, VA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, July-Aug. 1987, p. 342-348. Previously cited in issue 17, p. 2496, Accession no. A84-37491. refs

A88-11803*# Los Alamos National Lab., N. Mex.
INTEGRATED HEAT PIPE-THERMAL STORAGE SYSTEM PERFORMANCE EVALUATION
E. KEDDY, J. T. SENA, M. MERRIGAN (Los Alamos National Laboratory, NM), and GARY HEIDENREICH (Sundstrand Corp., Rockford, IL) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 183-187. Research supported by the Sundstrand Corp.
(Contract NAS3-24666)

An integrated thermal energy storage (TES) system, developed as a part of an organic Rankine cycle solar dynamic power system is described, and the results of the performance verification tests of this TES system are presented. The integrated system consists of potassium heat-pipe elements that incorporate TES canisters within the vapor space, along with an organic fluid heater tube used as the condenser region of the heat pipe. The heat pipe assembly was operated through the range of design conditions from the nominal design input of 4.8 kW to a maximum of 5.7 kW. The performance verification tests show that the system meets the functional requirements of absorbing the solar energy reflected by the concentrator, transporting the energy to the organic Rankine heater, providing thermal storage for the eclipse phase, and allowing uniform discharge from the thermal storage to the heater. I.S.

A88-11804*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FLUORIDE SALTS AND CONTAINER MATERIALS FOR THERMAL ENERGY STORAGE APPLICATIONS IN THE TEMPERATURE RANGE 973 - 1400 K
AJAY K. MISRA and J. DANIEL WHITTENBERGER (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 188-201. Previously announced in STAR as N87-24026. refs

Multicomponent fluoride salt mixtures were characterized for use as latent heat of fusion heat storage materials in advanced solar dynamic space power systems with operating temperatures in the range of 973 to 1400 K. The melting points and eutectic composition for many systems with published phase diagrams were verified, and several new eutectic compositions were identified. Additionally, the heats of fusion of several binary and ternary eutectics and congruently melting intermediate compounds were measured by differential scanning calorimetry. The extent of corrosion of various metals by fluoride melts was estimated from thermodynamic considerations, and equilibrium conditions inside a containment vessel were calculated as functions of the initial moisture content of the salt and free volume above the molten salt. Preliminary experimental data on the corrosion of commercial, high-temperature alloys in LiF-19.5CaF2 and NaF-27CaF2-36MgF2 melts are presented and compared to the thermodynamic predictions. Author

A88-11806*# LTV Aerospace and Defense Co., Dallas, Tex.
RADIATOR SELECTION FOR SPACE STATION SOLAR DYNAMIC POWER SYSTEMS
MIKE FLEMING (LTV Corp., LTV Missiles and Electronics Group, Dallas, TX) and FRANK HOEHN (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 208-213. NASA-supported research.

A study was conducted to define the best radiator for heat rejection of the Space Station Solar Dynamic Power System. Included in the study were radiators for both the Organic Rankine Cycle and Closed Brayton Cycle heat engines. A number of potential approaches were considered for the Organic Rankine Cycle and a constructable radiator was chosen. Detailed optimizations of this concept were conducted resulting in a baseline

for inclusion into the ORC Preliminary Design. A number of approaches were also considered for the CBC radiator. For this application a deployed pumped liquid radiator was selected which was also refined resulting in a baseline for the CBC preliminary design. This paper reports the results and methodology of these studies and describes the preliminary designs of the Space Station Solar Dynamic Power System radiators for both of the candidate heat engine cycles. Author

A88-11807*# Grumman Aerospace Corp., Bethpage, N.Y.
HEAT PIPE RADIATORS FOR SOLAR DYNAMIC SPACE POWER SYSTEM HEAT REJECTION
ERIC GUSTAFSON and ALBERT CARLSON (Grumman Aerospace Corp., Space Systems Div., Bethpage, NY) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 214-221. refs
(Contract NAS3-24665)

The paper presents the results of a concept development study of heat rejection systems for Space Station solar dynamic power systems. The thermal performance and weights of each of the heat rejection subsystems have been addressed in detail, and critical technologies which require development tests and evaluation for successful demonstration were assessed and identified. Baseline and several alternate heat rejection system configurations and optimum designs were developed for both Brayton and Rankine cycles. The thermal performance, mass properties, assembly requirements, reliability, maintenance requirements, and life cycle costs were determined for each of the system configurations. Trade studies were performed on each configuration with respect to the heat pipe wall thickness and the amount of redundancy to determine the effects on system reliability, maintenance requirements, and life cycle costs. An optimum design was then selected for each configuration. Author

A88-11809#
COMPARISON OF HIGH TEMPERATURE HEAT REJECTION CONCEPTS TO SYSTEM-RELATED REQUIREMENTS
LESTER L. BEGG and JOSEPH R. WETCH (Space Power, Inc., San Jose, CA) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 227-234. refs

Five concepts for heat rejection devices for space power systems were investigated: (1) liquid-droplet radiators, (2) moving-belt radiators, (3) Curie-point radiators, (4) rotating bubble membrane radiators, and (5) pump-loop and heat-pipe radiators. The concepts were compared for specific weight, stowable radiator area, launch capability, system integration, maneuverability, nuclear shielding, and survivability from natural and hostile threats. It is concluded that no one radiator system may best meet all requirements of all power systems; for each space power system a radiator system must be selected, which best satisfies the particularly weighted set of application criteria that apply to the mission, launch capability, power system, and platform components. It is noted that the present emphasis on specific weight may be misplaced. Geometric factors and deployability represent equally important issues. I.S.

A88-11810#
AN EVALUATION OF HEAT PIPE RADIATORS INCORPORATING PUMPED LIQUID RETURN
KEITH A. WOLOSHUN and MICHAEL A. MERRIGAN (Los Alamos National Laboratory, NM) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 235-240. refs

The capillary power limit encountered in long heat pipes for high-power, high-temperature heat rejection by radiation to space may be exceeded by incorporating external electromagnetic force pumps for enhanced liquid return. The hydrodynamic performance of capillary pumped heat pipes is compared with externally pumped heat pipes. Practical problems incurred with pump utilization are discussed. It is concluded that heat pipe radiator performance could be enhanced through external pumping under certain conditions, but, in general, power throughput requirements could be more readily achieved by other design changes. Pump implementation problems, including the required additional mass of the pumps, increased required radiator surface area for pump attachment, pump control requirements and pump power supply, are also discussed and evaluated. Author

A88-11874#
AUTOMATED TESTING AND INTEGRATION OF HETEROGENEOUS SYSTEMS
H. BIGLARI, J. O'NEILL, B. PURVES, R. WILLIAMS (Boeing Aerospace Co., Huntsville, AL), and J. SZTIPANOVITS (Vanderbilt University, Nashville, TN) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 2. New York, American Institute of Aeronautics and Astronautics, 1987, p. 623-627.

This paper describes a new test technology which has been developed to support the integration efforts of large-scale heterogeneous systems. The prototype was implemented to test and integrate highly coupled thermal and power systems of the Space Station. The Intelligent Test Integration System (ITIS) is a knowledge-based layer above the traditional test system components which can generate complex test configurations from the specification of the test scenarios. Author

A88-12006*# Little (Arthur D.), Inc., Cambridge, Mass.
PERFORMANCE CHARACTERISTICS OF MOVING BELT RADIATORS
D. MCFADDEN and W. P. TEAGAN (Arthur D. Little, Inc., Cambridge, MA) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 4. New York, American Institute of Aeronautics and Astronautics, 1987, p. 2029-2033. NASA-supported research.

A design features and performance capabilities evaluation is made for a novel, 'hybrid belt radiator' spacecraft heat rejection system, which retains the excellent heat transfer capacity of liquid belt radiators but does not require the direct exposure of a free liquid surface to the space environment. Attention is given to the preliminary results of a computer model analyzing the dynamic behavior of the flexible belt structure due to spacecraft accelerations, as well as to the results of system studies determining size constraints on the radiator. Over the 300-700 K range of operating temperatures, Space Shuttle-stowable radiators with 10-200 MW thermal capacities can be designed. O.C.

A88-14980
ON THE HIERARCHICAL CONTROL OF THE SPACE STATION COMMON MODULE THERMAL SYSTEM
F. LEWIS, J. CHENG, K. DAVEY, G. VACHTSEVANOS (Georgia Institute of Technology, Atlanta), and B. PURVES (Boeing Aerospace Co., Huntsville, AL) IN: IEEE Conference on Decision and Control, 25th, Athens, Greece, Dec. 10-12, 1986, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 868-872. Research supported by the Boeing Aerospace Co. refs

Bode plots of singular values vs. frequency were used to design several types of controllers for the Space Station common module Thermal Control System. Several controllers were designed, including a classical lead control loop with a multivariable disturbance input, and a multivariable output feedback controller. Singular value information was used to impose a hierarchical structure on the controller even though this structure was not natural to the plant; this permitted the design of local controllers with specified compensator structures; no undesirable additional dynamics in the form of observers or Kalman filters was needed. In addition, a method using singular values based on plant parameter variations was used to avoid gain scheduling. B.J.

A88-15806#
THERMAL DESIGN OF THE EQUIPMENT PLATFORMS
K. BADARI NARAYANA and S. U. KUMARI (Indian Space Research Organizaton, Satellite Centre, Bangalore, India) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 7 p. refs
(IAF PAPER 87-06)

The paper discusses the method of thermal analysis and design of the equipment platforms. The strongly implicit procedure of Stone (1968) is used for the solution of the governing nonlinear differential equations. Design results of regular and irregular shaped thermal doublers are presented and discussed. Some weight optimization studies are made. Due to the large number of constraints involved there are no general solutions available for optimizing the weight. However, the complete formulation and the solution method suggested in the paper can be used to make iterative studies for quick estimation of the weight of the doublers. Author

A88-15960*# Cleveland State Univ., Ohio.
MODELLING THE PERFORMANCE OF THE MONOGROOVE WITH SCREEN HEAT PIPE FOR USE IN THE RADIATOR OF THE SOLAR DYNAMIC POWER SYSTEM OF THE NASA SPACE STATION
AUSTIN LEWIS EVANS (Cleveland State University, OH) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 8 p. refs
(Contract NCC3-50)
(IAF PAPER 87-236)

A computer code to model the steady-state performance of a monogroove heat pipe for the NASA Space Station is presented, including the effects on heat pipe performance of a screen in the evaporator section which deals with transient surges in the heat input. Errors in a previous code have been corrected, and the new code adds additional loss terms in order to model several different working fluids. Good agreement with existing performance curves is obtained. From a preliminary evaluation of several of the radiator design parameters it is found that an optimum fin width could be achieved but that structural considerations limit the thickness of the fin to a value above optimum. R.R.

A88-17566
RADIATION CHARACTERISTICS OF OFFSET RADIAL RIB REFLECTOR ANTENNAS
D. LIZIUS and A. D. OLVER (Queen Mary College, London, England) IN: International Conference on Antennas and Propagation, 5th, York, England, Mar. 30-Apr. 2, 1987, Proceedings. Part 1. London, Institution of Electrical Engineers, 1987, p. 319-322.

This paper studies the radiation characteristics of offset radial rib reflector antennas. Consideration is given to the mathematical description of the reflector surface, phase error characterization, and the features of the radiation patterns. It is shown that the copolar pattern of an offset radial rib reflector is closely related to that of an axisymmetric radial rib reflector with a slightly scaled focal length. The qualitative effects of varying the diameter, the number of ribs, or the focal length on the pattern of a radial rib reflector are described. I.S.

A88-21083* Hughes Aircraft Co., Torrance, Calif.
HYBRID HONEYCOMB PANEL HEAT REJECTION SYSTEM
H. J. TANZER (Hughes Aircraft Co., Torrance, CA) and J. B. HALL, JR. (NASA, Langley Research Center, Hampton, VA) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 13 p. refs
(SAE PAPER 871419)

The evolution of a hybrid honeycomb panel heat rejection system concept for future high-power spacecraft is described. Performance evaluation of the heat pipe-based hybrid radiator is based on data and prediction models from a developmental component hardware testing program. The concept integrates three high-performance components into an optimized radiator system. These components are the sideflow heat pipe transport leg, honeycomb panel evaporator, and light-weight high-efficiency heat pipe fins. A 3.05 m (10 ft.) long hybrid radiator was designed considering remnant hardware available from other Hughes programs. The key performance objective for the hybrid radiator was to demonstrate high thermal transport capacity, increased radiating fin lengths, improved thermal efficiency across structural boundaries, and reduced weight. Analysis showed that 9000 W can be transported over a 3.05 m radiator and that finlengths of up to 1 m are possible. Author

A88-21085
ITDS - A PROGRAM FOR INTERACTIVE DESIGN AND ANALYSIS OF ADVANCED ACTIVE THERMAL CONTROL SYSTEMS
P. JEFF BERTSCH (McDonnell Douglas Astronautics Co., Houston, TX) and JOE P. CHAMBLISS (Lockheed Engineering and Management Services Co., Houston, TX) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 22 p. refs
(SAE PAPER 871421)

The Interactive Thermal Design System (ITDS) is a new computer program developed specifically to support design and analysis of advanced spacecraft Active Thermal Control Subsystems (ATCSs). The program was developed for NASA/JSC during 1985 and 1986 to provide design and analytical support needed for projects such as the Space Station and space platforms. ITDS uses modern computing techniques, VAX computing machinery, and commercial database and graphics software to greatly improve the productivity of design and analytical efforts. The program uses interactive menus to control technical and supporting functions combined with graphical system representation to streamline the design and analysis process. The ITDS library of single and two-phase ATCS routines accommodates design and analysis of single components or integrated systems. Supporting utilities provide units conversion, easily selected and accessed fluid property data for twenty ATCS fluids, and help data to assist the user with program functions. This paper describes the development of ITDS, the features it offers and examples of how it may be employed. Author

A88-21104
PUMPED TWO-PHASE AMMONIA THERMAL BUS TEST BED
MICHAEL P. MCHALE, STEVE D. GOO, and J. C. PIZZICHEMI (Boeing Aerospace Co., Seattle, WA) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 6 p.
(SAE PAPER 871442)

Future large spacecraft such as the Space Station will have high power dissipations and long heat transport distances. The combination of these two requirements dictate the need for a new heat transport technology. NASA-JSC has developed the concept of a two phase thermal bus in which the working fluid is evaporated at the heat collection site and is condensed at the heat rejection site. This provides a nearly isothermal system at lower pumping powers than current single phase systems. Boeing has developed a two-phase thermal bus testbed using ammonia working fluid. This testbed uses a Sundstrand rotary fluid management device (RFMD) to provide fluid pumping and liquid-vapor phase management. Overall heat transport capacity is 25 kW. This internally funded testbed is being used for thermal bus heat exchanger characterization and critical component life tests in an ammonia environment. Currently, the testbed has been assembled, proof-pressure tested, leak tested, and checked out. Heat exchanger performance tests are underway. Author

A88-21129* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
DEVELOPMENT OF A THERMAL CONTROL COATING FOR SPACE SUITS
BERNADETTE SQUIRE and BRUCE WEBBON (NASA, Ames Research Center, Moffett Field, CA) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987.

11 p. refs
(SAE PAPER 871474)

Past space suits and the current Shuttle suit, which are constructed primarily from fabric, use the Integrated Thermal and Micrometeoroid Garment, which insulates the astronaut from his environment. The new generation of hard suits affords designers the opportunity to incorporate thermal control into the suit structure. Environmental influence on the suit temperature and heat flux can then be minimized with a high reflectance coating. Candidate coatings have been identified and ranked on the basis of thermophysical properties, wear, corrosion and atomic oxygen degradation resistance, and coating process and cost. Laboratory determination of properties, thermal cycling and wear resistance tests are underway to identify the optimum coating. A computer model is being developed to evaluate various environmental configurations. Preliminary results are presented here. Author

A88-21151* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
PRELIMINARY DESIGN OF THE SPACE STATION INTERNAL THERMAL CONTROL SYSTEM
MARK T. HERRIN, DAVID W. PATTERSON, and LARRY D. TURNER (NASA, Marshall Space Flight Center, Huntsville, AL) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 13 p. refs
(SAE PAPER 871505)

The baseline preliminary design configuration of the Internal Thermal Control system (ITCS) of the U.S. Space Station pressurized elements (i.e., the Habitation and U.S. Laboratory modules, pressurized logistics carrier, and resources nodes) is defined. The ITCS is composed of both active and passive components. The subsystems which comprise the ITCS are identified and their functional descriptions are provided. The significant trades and analyses, which were performed during Phase B (i.e., the preliminary design phase) that resulted in the design described herein, are discussed. The ITCS interfaces with the station's central Heat Rejection and Transport System (HRTS), other systems, and externally attached pressurized payloads are described. Requirements on the ITCS with regard to redundancy and experiment support are also addressed. Author

A88-21152* Grumman Aerospace Corp., Bethpage, N.Y.
DESIGN OF AN AMMONIA TWO-PHASE PROTOTYPE THERMAL BUS FOR SPACE STATION
RICHARD F. BROWN, ERIC GUSTAFSON (Grumman Corp., Space Systems Div., Bethpage, NY), and RICHARD PARISH (NASA, Johnson Space Center, Houston, TX) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 12 p. refs
(SAE PAPER 871506)

The feasibility of two-phase heat transport systems for use on Space Station was demonstrated by testing the Thermal Bus Technology Demonstrator (TBTD) as part of the Integrated Two-Phase System Test in NASA-JSC's Thermal Test Bed. Under contract to NASA-JSC, Grumman is currently developing the successor to the TBTD, the Prototype Thermal Bus System (TBS). The TBS design, which uses ammonia as the working fluid, is intended to achieve a higher fidelity level than the TBTD by incorporating both improvements based on TBTD testing and realistic design margins, and by addressing Space Station issues such as redundancy and maintenance. The TBS is currently being fabricated, with testing scheduled for late 1987/early 1988. This paper describes the TBS design which features fully redundant plumbing loops, five evaporators designed to represent different heat acquisition interfaces, 14 condensers which mate with either space radiators or facility heat exchangers, and several modular components. Author

A88-21153* LTV Missiles and Electronics Group, Dallas, Tex.
SPACE STATION BODY MOUNTED RADIATOR DESIGN
M. L. FLEMING and R. J. DUSCHATKO (LTV Corp., Missiles Div., Dallas, TX) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 9 p.
(Contract NAS8-36402)
(SAE PAPER 871507)

Consideration has been given to utilizing the external area of the Space Station common modules or resource nodes to provide heat rejection. A program was undertaken to define the best body mounted radiator design, to define and build a full size test article and to conduct testing to verify performance. Trade studies were conducted and a preferred design selected. The selected design employed high performance grooved heat pipes of an off-the-shelf design. Twenty panels, each about 1.2 m wide by 5.6 m long are installed on each module rejecting a total of about 12 kW. The radiators are interfaced with the module thermal control loop by use of a refrigerant 21 loop with an on-orbit operable disconnect at each panel. A one-panel test article has been designed and is currently being fabricated. Testing is scheduled to be conducted in June of 1987. Author

A88-21154
THE SPACEHAB MODULE PASSIVE THERMAL CONTROL
ROBERT CITRON, THOMAS C. TAYLOR, E. VALLERANI, and LAZZARO COSTAMAGNA (SPACEHAB, Inc., Seattle, WA) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 8 p.
(SAE PAPER 871508)

The NASA Space Shuttle-launched Spacehab module is a pressurized volume for human habitation that will furnish expanded experimental facilities in orbit. It is scheduled for operation in 1990, and will double the pressurized volume of the middeck locker volume of the Space Shuttle Orbiter. Attention is presently given to an Italian passive thermal control system concept for Spacehab, taking the form of multilayer insulation (MLI). Teflon-coated fiberglass cloth and single- and double-aluminized Kapton are employed in the MLI system. O.C.

A88-21155* Grumman Aerospace Corp., Bethpage, N.Y.
HIGH THERMAL-TRANSPORT CAPACITY HEAT PIPES FOR SPACE RADIATORS
ALBERT W. CARLSON, ERIC GUSTAFSON, and SUSAN L. ROUKIS (Grumman Corp., Space Systems Div., Bethpage, NY) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 14 p. refs
(Contract NAS3-24665)
(SAE PAPER 871509)

This paper presents the results of performance tests of several dual-slot heat pipe test articles. The dual-slot configuration has a very high thermal transport capability and has been identified as a very promising candidate for the radiator system for the NASA Space Station solar dynamic power modules. Two six-foot long aluminum heat pipes were built and tested with ammonia and acetone. A 20-ft long heat pipe was also built and tested with ammonia. The test results have been compared with performance predictions. A thermal transport capacity of 2000 W at an adverse tilt of 1 in. and a 1000 W capacity at an adverse tilt of 2 in. were achieved on the 20-ft long heat pipe. These values are in close agreement with the predicted performance limits. Author

A88-22342#
THERMAL CONTACT CONDUCTANCE IN THE PRESENCE OF THIN METAL FOILS
G. P. PETERSON and L. S. FLETCHER (Texas A & M University, College Station) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. Research sponsored by Texas A & M University. refs
(AIAA PAPER 88-0468)

Techniques for enhancing the thermal joint conductance through the use of interstitial materials is of particular importance at the interfaces existing between the proposed Space Station thermal utility, which collects waste heat from within the habitation module and transports it to the radiators, and the individual radiator components. A brief review of the past experimental and analytical investigations relating to the use of thin metallic foils for enhancing the thermal conductance at metallic junctions is presented, along

with the results of an experimental program designed to evaluate the thermal contact conductance of Aluminum 6061 T6 interfaces with varying degrees of roughness and four different soft metallic foils. Using a previously developed method for determining the optimum thickness, the effects of surface roughness along with foil hardness and foil thermal conductivity were evaluated. Results indicate that for a given foil thickness, an optimum surface roughness exists and by using an optimum foil thickness in conjunction with the optimum surface roughness, the thermal contact conductance can be increased by as much as a factor of seven over the bare joint values. Author

A88-22343*# LTV Missiles and Electronics Group, Dallas, Tex.
THERMAL CONTACT CONDUCTANCE OF PRESSURIZED SURFACES
FRED E. VOSS (LTV Corp., Missiles Div., Dallas, TX) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 7 p.
(Contract NAS9-17327)
(AIAA PAPER 88-0467)

Thermal vacuum testing has demonstrated the feasibility of the concept of pressurizing contact surfaces for the transfer of waste heat on the Space Station. Data show a thin inflatable bladder design to provide a greater contact conductance than an expandable bellows approach, with substantially less interface volume to transfer the same amount of heat. Extended vacuum testing of the Radiator-to-Thermal Bus assembly indicated a continual increase of conductance as the interface was maintained at 150 psi for a 100-hour period. R.R.

A88-22345*# LTV Missiles and Electronics Group, Dallas, Tex.
SPACE ERECTABLE RADIATOR SYSTEM DEVELOPMENT
J. A. OREN (LTV Corp., Missiles Div., Dallas, TX) and H. R. HOLMES (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 14 p. refs
(Contract NAS9-17495)
(AIAA PAPER 88-0469)

The NASA Space Station's Space Erectable Radiator System features modular radiator panels with high-capacity tapered artery heat pipes bonded within their aluminum honeycomb structures. Simple, dry aluminum-to-aluminum thermal contact surfaces are used for the connections, thereby requiring no fluid joints; a uniformly distributed clamping force at the radiator panel-to-thermal transport loop interface heat exchange surface yields high thermal contact conductance as well as minimum area and weight for the requisite performance. The design has been optimized for weight and cost. O.C.

A88-22347*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LARGE DEPLOYABLE REFLECTOR THERMAL CHARACTERISTICS IN LOW EARTH ORBITS
Y. C. WU and R. N. MIYAKE (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. refs
(AIAA PAPER 88-0471)

Preliminary results are presented from the development of a thermal analytical tool capable of analyzing the orbital thermal characteristics of a Large Deployable Reflector (LDR) spaceborne astronomical instrument for observations in the 30-micron to 1-mm range. This LDR thermal analytical tool is a 9X6-node reflector thermal model to be used in conjunction with the thermal analyzer program SINDA, as well as the orbital heat flux program TRASYS for the computation of solar and IR radiation and orbit-related input data. O.C.

A88-22349*# Lockheed Engineering and Management Services Co., Inc., Houston, Tex.
SPACE STATION ACTIVE THERMAL CONTROL SYSTEM MODELING
ABDUL HYE (Lockheed Engineering and Management Services Co., Inc., Houston, TX) and CHIN H. LIN (NASA, Johnson Space Center, Houston, TX) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(Contract NAS9-15800)
(AIAA PAPER 88-0473)

The Space Station Active Thermal Control System (ATCS) has been modeled using modified SINDA/SINFLO programs to solve two-phase Thermo-fluid problems. The modifications include changes in several subroutines to incorporate implicit solution which allows larger time step as compared to that for explicit solutions. Larger time step saves computer time but involves larger computational error. Several runs were made using various time steps for the ATCS model. It has been found that for a reasonable approach, three times larger time step as compared to that used in explicit method is a good value which will reduce the computer time by approximately 50 percent and still maintain the accuracy of the output data to within 90 percent of the explicit values. Author

A88-25368
NEW RADIATOR SYSTEM DESIGNED FOR LARGE SPACECRAFT
Aerospace Engineering (ISSN 0736-2536), vol. 8, Jan. 1988, p. 52-56.

NASA has conducted intensive design investigations into the possible technologies and configurations of future high power spacecraft heat rejection systems, whose requirements will typically involve carrying 50-100 kW of heat over 10-20 m distances. Attention is presently given to a hybrid thermal rejection system employing a honeycomb panel evaporator, a sideflow heat pipe, and heat pipe panel radiator fins. The flattening of effective heat transfer area and the grooving of the condensation side of the common wall employed are found to substantially improve sideflow-to-fin element temperature drop. O.C.

A88-25979
THERMAL ENVIRONMENT SIMULATOR FOR VACUUM TESTING OF LARGE SPACECRAFT
T. S. MARSHALL (Martin Marietta Corp., Denver, CO) (Institute of Environmental Sciences and Aerospace Corp., Aerospace Testing Seminar, 10th, Los Angeles, CA, Mar. 10-12, 1987) Journal of Environmental Sciences (ISSN 0022-0906), vol. 31, Jan.-Feb. 1988, p. 29-32, 49.

A thermal environment simulator (TES) with 56 independently controllable temperature zones has been developed for Martin Marietta's Space Simulation Laboratory. This simulator is designed to test Shuttle payloads in a thermal vacuum chamber with liquid nitrogen cloud walls. The thermal environment simulator is an alternative to a 4.9-m (16-ft) diameter vertical beam solar simulator and two-axis gimbal system. The simulator can accommodate larger test articles at a lower cost. It provides complex heat flux distributions by surrounding the test articles with a multifaceted temperature environment. Issues resolved during initial operation included vacuum and cryogenic compatibility, control capabilities, instrumentation, calibration, heat flux uniformity, and reliability. Author

A88-30320#
ROLL-OUT-FIN EXPANDABLE SPACE RADIATOR CONCEPT
R. PONNAPPAN (Universal Energy Systems, Inc., Dayton, OH), J. E. BEAM, and E. T. MAHEFKEY (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) Journal of Thermophysics and Heat Transfer (ISSN 0887-8722), vol. 2, Jan. 1988, p. 91-94. USAF-sponsored research. Previously cited in issue 18, p. 2621, Accession no. A86-39924. refs

N88-10094*# Grumman Aerospace Corp., Bethpage, N.Y.
THERMAL CONTROL WORKING GROUP REPORT
ROBERT HASLETT and E. THOMAS MAHEFKEY (Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.) *In* NASA-Lewis Research Center, Spacecraft 2000 p 135-147 Jul. 1986
Avail: NTIS HC A11/MF A01 CSCL 22B

The Thermal Control Working Group limited its evaluation to issues associated with Earth orbiting and planetary spacecraft with

power levels up to 50 kW. It was concluded that the space station technology is a necessary precursor but does not meet S/C 2000 needs (life, high heat flux, long term cryogenics, and survivability). Additional basic and applied research are required (fluid/materials compatibility and two phase system modeling). Scaling, the key issue, must define accelerated life test criteria. The two phase systems require 0g to 1 g correlation. Additional ground test beds are required and combined space environment tests of materials. B.G.

N88-11738# Sandia National Labs., Albuquerque, N. Mex.
ESTIMATING PAYLOAD INTERNAL TEMPERATURES AND RADIATOR SIZE FOR MULTIMEGAWATT SPACE PLATFORMS
DEAN DOBRANICH Aug. 1987 74 p
(Contract DE-AC04-76DP-00789)
(DE88-000244; SAND-87-1216) Avail: NTIS HC A04/MF A01

A conceptual space platform consists of a payload, a power conditioning unit (PCU), and two radiators: the main radiator and a secondary radiator. A computer program was written to determine the required size of the two radiators and the temperatures of the PCU and payload for a given platform power level. An iterative approach is necessary because the required size of the main radiator depends on the size of the secondary radiator and vice versa. Also, the temperatures of the payload and PCU depend on the size of the radiators. The program user can subdivide the two radiators into any number of nodes to increase the accuracy of the radiant heat transfer solution. The use of more nodes also allows better prediction of the nonlinear temperature drop that occurs across the radiators as the working fluid deposits the platform's waste heat in the radiator. View factor expressions are automatically calculated for different choices of the number of nodes. The user can also select different separation distances between the various platform structures. A model is included to couple the radiant and conduction heat transfer that occurs between the payload and its meteoroid shell and between the PCU and its shell. DOE

N88-11739# National Aerospace Lab., Amsterdam (Netherlands). Space Div.
CONSIDERATIONS CONCERNING A THERMAL JOINT FOR A DEPLOYABLE OR STEERABLE BATTERY RADIATOR FOR THE COLUMBUS POLAR PLATFORM
A. A. M. DELIL 6 Jun. 1986 41 p Sponsored in part by Fokker B.V.
(NLR-TR-86055-U; B8709830; ETN-87-91331) Avail: NTIS HC A03/MF A01

Concepts for a moveable thermal joint are discussed with respect to the applicability in a dedicated deployable or steerable heat pipe radiator system to handle the waste heat of the NiH batteries of the Polar Platform. Possible candidates for near-term deployable radiator development are: the flexible heat pipe; the low-melting-point alloy filled, grease filled, or low pressure helium gas filled (finned) heat exchanger; the braided conductor (having high mass and retraction torque); and the clamped contact. The flexible heat pipe is less attractive for steerable radiator applications. The braided conductor and the clamped contact are inadequate. The nonsolid material filled heat exchanger is the preferable joint if steerability is required. ESA

N88-12504# Joint Publications Research Service, Arlington, Va.
SOLAR CONVERGING METHOD
In its JPRS Report: Science and Technology. Japan p 3-5 24 Aug. 1987 Transl. into ENGLISH from Nikko Materials (Tokyo, Japan) Feb. 1987 p 35-36
Avail: NTIS HC A06/MF A01

Reflective mirror segments have been developed to form the basis of the light-condensing units for solar condensers for space stations. One type (A), a carbon fiber reinforced plastic (CFRP) skin surrounding an aluminum honeycomb structure, aims for a high degree of precision in the mirror surface. A second type (B) is constructed from a surface skin alone and is extremely light in weight. For both, the surface roughness was 0.03. Reflectivity was 85.5 percent for Type A and 89.5 percent for Type B. In terms of condensivity, light traveling parallel to the mirror axis fell within a 3 by 3 mm area on a position detection sensor located 1,600 mm from the mirror surface for Type A, with most of the light falling within 1 mm from the center, while for Type B the light was concentrated within a 10 by 10 mm area. At this distance, the spreading of light waves due to spherical aberration is expected to be slightly under 2 mm for an ideal spherical surface, so that Type A shows a very good degree of precision. J.P.B.

N88-12747*# Hughes Aircraft Co., Torrance, Calif. Electron Dynamics Div.
ADVANCED RADIATOR CONCEPTS UTILIZING HONEYCOMB PANEL HEAT PIPES Final Technical Report, Jun. 1982 - Jun. 1987
G. L. FLEISCHMAN, S. J. PECK, and H. J. TANZER Oct. 1987 107 p
(Contract NAS9-16581; NASA ORDER W-30746)
(NASA-CR-172017; NAS 1.26:172017) Avail: NTIS HC A06/MF A01 CSCL 20D

The feasibility of fabricating and processing moderate temperature range vapor chamber type heat pipes in a low mass honeycomb panel configuration for highly efficient radiator fins for potential use on the space station was investigated. A variety of honeycomb panel facesheet and core-ribbon wick concepts were evaluated within constraints dictated by existing manufacturing technology and equipment. Concepts evaluated include type of material, material and panel thickness, wick type and manufacturability, liquid and vapor communication among honeycomb cells, and liquid flow return from condenser to evaporator facesheet areas. A thin-wall all-welded stainless steel design with methanol as the working fluid was the initial prototype unit. It was found that an aluminum panel could not be fabricated in the same manner as a stainless steel panel due to diffusion bonding and resistance welding considerations. Therefore, a formed and welded design was developed. The prototype consists of ten panels welded together into a large panel 122 by 24 by 0.15 in., with a heat rejection capability of 1000 watts and a fin efficiency of essentially 1.0. Author

N88-13381# Sandia National Labs., Albuquerque, N. Mex.
THE EFFECT OF MAXIMUM-ALLOWABLE PAYLOAD TEMPERATURE ON THE MASS OF A MULTIMEGAWATT SPACE-BASED PLATFORM
D. DOBRANICH Aug. 1987 48 p
(Contract DE-AC04-76DP-00789)
(DE88-001921; SAND-87-1449) Avail: NTIS HC A03/MF A01

Calculations were performed to determine the mass of a space-based platform as a function of the maximum-allowed operating temperature of the electrical equipment within the platform payload. Two computer programs were used in conjunction to perform these calculations. The first program was used to determine the mass of the platform reactor, shield, and power conversion system. The second program was used to determine the mass of the main and secondary radiators of the platform. The main radiator removes the waste heat associated with the power conversion system and the secondary radiator removes the waste heat associated with the platform payload. These calculations were performed for both Brayton and Rankine cycle platforms with two different types of payload cooling systems: a pumped-loop system (a heat exchanger with a liquid coolant) and a refrigerator system. The results indicate that increases in the maximum-allowed payload temperature offer significant platform mass savings for both the Brayton and Rankine cycle platforms with either the pumped-loop or refrigerator payload cooling systems. Therefore, with respect to platform mass, the development of high temperature electrical equipment would be advantageous. DOE

N88-15823*# Georgia Inst. of Tech., Atlanta. School of Mechanical Engineering.
DEVELOPMENT OF AN EMULATION-SIMULATION THERMAL CONTROL MODEL FOR SPACE STATION APPLICATION Final Report
JAMES G. HARTLEY and GENE T. COLWELL Jan. 1988 88 p

(Contract NAG1-551)
(NASA-CR-182409; NAS 1.26:182409) Avail: NTIS HC A05/MF A01 CSCL 22B

The goal of this program is to develop an improved capability for comparing various techniques for thermal management in the space station. The work involves three major tasks: Develop a Technology Options Data Base (Task 1); Complete Development of a Space Station Thermal Control Technology Assessment Program (Task 2); and Develop and Evaluate Emulation Models (Task 3). Author

N88-15828# Fokker B.V., Amsterdam (Netherlands). Space Div.
THERMAL STRUCTURAL CONTROL MODELLING TECHNIQUES Final Report
J. J. WIJKER Paris, France ESA 12 Jun. 1986 110 p
(Contract ESTEC-5158/82-NL-PB(SC))
(FOK-TR-R-86-030; ESA-CR(P)-2496; ETN-88-91704) Avail: NTIS HC A06/MF A01

A link between the ASKA finite element program and the Dynamic and Control Analysis Package (DCAP) was developed. An interface software package called Interface DCAP (IFDCAP) was generated to transfer numerical data, describing the structural behavior of flexible bodies, between ASKA and DCAP. Ten test cases were defined in order to demonstrate the functioning of the interface program. Methodologies and links for data transfer between the System Improved Numerical Differencing Analyzer (SINDA) and ASKA were established. A temperature interpolation technique based on the prescribed average technique was developed. Using the finite element model of the structure with its conduction matrix, the thermal model temperatures are interpolated to obtain temperatures in all nodes of the structural model. A software package called SINAS to transfer SINDA nodal temperatures to the ASKA model nodes was written. Four test cases to demonstrate the functional performance of the interface package SINAS were defined. ESA

05

ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS

Includes description of analytical techniques and models, trade studies of technologies, subsystems, support strategies, and experiments for internal and external environmental control and protection, life support systems, human factors, life sciences and safety.

A88-13162
MEDICAL ASPECTS OF ORBITAL SPACEFLIGHT AND THEIR IMPLICATIONS FOR MANUFACTURING IN SPACE
GEORGE T. DELLI-SANTI (Zimmer, Inc., Warsaw, IN) IN: Advanced materials technology '87; Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr. 6-9, 1987. Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 484-496. refs

A general review of the biomedical consequences of prolonged orbital spaceflight is presented. Data from Apollo, Skylab and Soviet space programs is used to describe a number of the physiologic changes associated with adaptation to a microgravity environment. The author concludes by speculating on how these medical aspects may influence the design and development of orbital manufacturing facilities. Author

A88-15963#
ASPECTS AND POSSIBILITIES OF AN INTEGRATED ENERGY AND MEDIA SUPPLY SYSTEM ON H2/O2-BASIS FOR MANNED SPACE STATIONS IN THE LOW EARTH ORBIT
B. OBERLE and M. FISCHER (DFVLR, Institut fuer Technische Thermodynamik, Stuttgart, Federal Republic of Germany) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 9 p. refs
(IAF PAPER 87-241)

A combined electrolyzer/fuel cell system based on H2/O2 for a manned space station in the low earth orbit is proposed which offers the possibility of coupling the energy supply system with the fuel supply system for orbit keeping as well as with the life support system for the crew. An H2/O2 integrated energy and media supply system is advantageous for such tasks as energy storage for the dark period when operating photovoltaic systems; supply of user-oriented power profiles; load management; power supply during emergencies, phases of station buildup, maintenance, and reconstruction; and thermal energy supply. The typical characteristics of the system are presented. V.L.

A88-16166*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
HUMAN FACTOR DESIGN OF HABITABLE SPACE FACILITIES
YVONNE A. CLEARWATER (NASA, Ames Research Center, Moffett Field, CA) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 10 p. refs
(IAF PAPER 87-549)

Current fundamental and applied habitability research conducted as part of the U.S. space program is reviewed with emphasis on methods, findings, and applications of the results to the planning and design of the International Space Station. The discussion covers the following six concurrent directions of habitability research: operational simulation, functional interior decor research, space crew privacy requirements, interior layout and configuration analysis, human spatial habitability model, and analogous environments research. V.L.

A88-17072
VAPOR COMPRESSION DISTILLER AND MEMBRANE TECHNOLOGY FOR WATER REVITALIZATION
A. ASHIDA (Hitachi, Ltd., Space Systems Div., Tokyo, Japan), K. MITANI (Hitachi, Ltd., Space Systems Div., Yokohama, Japan), K. EBARA, H. KUROKAWA (Hitachi, Ltd., Japan), I. SAWADA (Sasakura Engineering Co., Ltd., Osaka, Japan) et al. (COSPAR and International Academy of Astronautics, Plenary Meeting, 26th, Workshop on Controlled Ecological Life Support Systems, 2nd, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 7, no. 4, 1987, p. 73-76.

A88-21076
A DISHWASHER FOR THE SPACE STATION
R. GARY WILSON and JON D. TROMBLEE (Whirlpool Corp., Evansville, IN) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 11 p.
(SAE PAPER 871411)

This paper describes a dishwasher ground test unit which has been designed to wash eating utensils in the microgravity environment of the Space Station. The basic wash process is described as well as the methods used for controlling the wash and rinse water. The required interfaces to the Space Station are discussed and the amount of resources consumed during a complete wash cycle are presented. The paper is concluded with a discussion of several growth versions of the dishwasher which will accommodate increases in the number of crew persons on board the Space Station. Author

A88-21077* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ACCOMMODATING LIFE SCIENCES ON THE SPACE STATION
ROGER D. ARNO (NASA, Ames Research Center, Moffett Field, CA) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 8 p. refs
(SAE PAPER 871412)

The NASA Ames Research Center Biological Research Project (BRP) is responsible for identifying and accommodating high priority life science activities, utilizing nonhuman specimens, on the Space Station and is charged to bridge the gap between the science

community and the Space Station Program. This paper discusses the approaches taken by the BRP in accomodating these research objectives to constraints imposed by the Space Station System, while maintaining a user-friendly environment. Consideration is given to the particular research disciplines which are given priority, the science objectives in each of these disciplines, the functions and activities required by these objectives, the research equipment, and the equipment suits. Life sciences programs planned by the Space Station participating partners (USA, Europe, Japan, and Canada) are compared. I.S.

A88-21078* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
OSSA SPACE STATION WASTE INVENTORY
DARYL N. RASMUSSEN, CATHERINE C. JOHNSON (NASA, Ames Research Center, Moffett Field, CA), JOHN J. BOSLEY, GEORGE L. CURRAN (Bionetics Corp., Moffett Field, CA), and RICHARD MAINS (Mains Associates, Berkeley, CA) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 8 p. refs
(SAE PAPER 871413)

NASA's Office of Space Science and Applications has compiled an inventory of the types and quantities of the wastes that will be generated by the Space Station's initial operational phase in 35 possible mission scenarios. The objective of this study was the definition of waste management requirements for both the Space Station and the Space Shuttles servicing it. All missions, when combined, will produce about 5350 kg of gaseous, liquid and solid wastes every 90 days. A characterization has been made of the wastes in terms of toxicity, corrosiveness, and biological activity. O.C.

A88-21081* Rockwell International Corp., Downey, Calif.
ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS ANALYSIS FOR A SPACE STATION LIFE SCIENCES ANIMAL EXPERIMENT
KENNETH T. SO (Rockwell International Corp, Downey, CA), JOHN B. HALL, JR. (NASA, Langley Research Center, Hampton, VA), and CLIFFORD D. THOMPSON (NASA, Johnson Space Center, Houston, TX) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 13 p. refs
(SAE PAPER 871417)

NASA's Langley and Goddard facilities have evaluated the effects of animal science experiments on the Space Station's Environmental Control and Life Support System (ECLSS) by means of computer-aided analysis, assuming an animal colony consisting of 96 rodents and eight squirrel monkeys. Thirteen ECLSS options were established for the reclamation of metabolic oxygen and waste water. Minimum cost and weight impacts on the ECLSS are found to accrue to the system's operation in off-nominal mode, using electrochemical CO2 removal and a static feed electrolyzer for O2 generation. O.C.

A88-21090
G189 COMPUTER PROGRAM MODELING OF ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS FOR THE SPACE STATION
ROBERT S. BARKER, KENNETH T. SO, and MARC J. DEBARRO (Rockwell International Corp., Space Station Systems Div., Downey, CA) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 18 p.
(SAE PAPER 871427)

The initial development and subsequent evolution of the environmental control and life support system (ECLSS) for the manned Space Station requires a numerical modeling computer program that can accurately simulate the ECLSS. The G189 program has successfully provided this modeling function for the Skylab refrigeration system and for the environmental control system in the Space Shuttle Orbiter. Recent developments at Rockwell International are presented here for a user-friendly computer program for facilitating G189 program input data preparation, and a Space Station ECLSS model simulation. For this paper, a candidate Space Station ECLSS configuration was modeled. Functions modeled included O2 generation, CO2 removal, CO2 reduction, water recovery, cabin atmosphere composition and pressure control, cabin temperature and humidity control, and trace contaminant control. Author

A88-21092
ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM FOR JAPANESE EXPERIMENT MODULE
K. SHIRAKI (National Space Development Agency of Japan, Tokyo), H. FUJIMORI, and A. HATTORI (Kawasaki Heavy Industries, Ltd., Kobe, Japan) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 11 p.
(SAE PAPER 871429)

As a result of the preliminary study for the environmental control and life support system (ECLSS) of the Japanese Experimental Module (JEM), the functions of the JEM ECLSS are defined as follows: atmosphere control and supply, temperature and humidity control (including intramodule and intermodule air ventilation), atmosphere revitalization (CO2 removal, contamination control and monitoring), fire detection and suppression, water management, and rescue provision, while the supply and recovery/processing of gas and water depend on the Space Station core ECLSS. Also, advanced technology developments for cabin air flow distribution system, regenerative CO2 removal system, and gas/water separating system were performed. Author

A88-21096* Life Systems, Inc., Cleveland, Ohio.
ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM REQUIREMENTS AND TECHNOLOGY NEEDS FOR ADVANCED MANNED SPACE MISSIONS
FEROLYN T. POWELL (Life Systems, Inc., Cleveland, OH), MELAINE SEDEJ, and CHIN LIN (NASA, Johnson Space Center, Houston, TX) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 15 p.
(SAE PAPER 871433)

NASA has completed an environmental control and life support system (ECLSS) technology R&D plan for advanced missions which gave attention to the drivers (crew size, mission duration, etc.) of a range of manned missions under consideration. Key planning guidelines encompassed a time horizon greater than 50 years, funding resource requirements, an evolutionary approach to goal definition, and the funding of more than one approach to satisfy a given perceived requirement. Attention was given to the ECLSS requirements of transportation and service vehicles, platforms, bases and settlements. ECLSS functions and average load requirements, unique drivers for various missions, and potentially exploitable commonalities among vehicles and habitats. O.C.

A88-21098
LIGHTING CONSIDERATIONS IN A CONTROLLED ENVIRONMENTAL LIFE SUPPORT SYSTEM
M. W. OLESON, T. J. SLAVIN, and R. L. OLSON (Boeing Aerospace Co., Seattle, WA) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 11 p.
(SAE PAPER 871435)

Plant growth lighting design options are explored for CELSS type systems. Plant lighting systems are reviewed for terrestrial horticulture applications and then extrapolated for use on space vehicles. Several in-space lighting systems are discussed as to their relative merits from both a biological and engineering viewpoint. Two promising candidate CELSS lighting systems are described in detail. One of these is an indirect solar illumination concept using fiber optic technology. Finally, interim results from an orbital lighting cycle plant growth experiment are presented. These experiments provide data on various plants grown under lighting conditions that could result from using solar illumination techniques. The lighting conditions are based on low earth orbit Space Station's orbital cycles. The primary objective in these experiments is to determine maximum plant food production with minimum electrical power consumption. Author

A88-21106* Hamilton Standard, Windsor Locks, Conn.
THERMOELECTRIC INTEGRATED MEMBRANE EVAPORATION SUBSYSTEM TESTING
GERARD F. DEHNER (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) and DON F. PRICE (NASA, Johnson Space Center, Houston, TX) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 7 p. refs
(SAE PAPER 871446)

An advanced preprototype Thermoelectric Integrated Membrane Evaporation Subsystem (TIMES) has been developed to provide high quality water recovery from various types of wastewater on extended duration space flights. The subsystem has undergone extensive wastewater processing testing, in order to evaluate its potential as an essential part of the Space Station Water Reclamation System. A discussion of the operating performance of the TIMES is presented in this paper, with special attention given to the water quality attained for a number of simulated Space Station wastewater feedstocks. Author

A88-21107* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
RECENT DEVELOPMENTS IN WATER QUALITY MONITORING FOR SPACE STATION RECLAIMED WASTEWATERS
JOHN W. SMALL (Astro International Corp., Houston, TX), CHARLES E. VEROSTKO (NASA, Johnson Space Center, Houston, TX), ARTHUR T. LINTON (Hamilton Standard Management Services, Houston, TX), and RAY BURCHETT (Phoenix Electrodes, Inc., Houston, TX) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 9 p. refs
(SAE PAPER 871447)

This paper discusses the recent developments in water quality monitoring for Space Station reclaimed wastewaters. A preprototype unit that contains an ultraviolet absorbance organic carbon monitor integrated with pH and conductivity sensors is presented. The preprototype has provisions for automated operation and is a reagentless flow-through system without any gas/liquid interfaces. The organic carbon monitor detects by ultraviolet absorbance the organic impurities in reclaimed wastewater which may be correlated to the organic carbon content of the water. A comparison of the preprototype organic carbon detection values with actual total organic carbon measurements is presented. The electrolyte double junction concept for the pH sensor and fixed electrodes for both the pH and conductivity sensors are discussed. In addition, the development of a reagentless organic carbon analyzer that incorporates ultraviolet oxidation and infrared detection is presented. Detection sensitivities, hardware development, and operation are included. Author

A88-21108* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
THE SPACE STATION AIR REVITALIZATION SUBSYSTEM DESIGN CONCEPT
C. D. RAY, K. Y. OGLE, R. W. TIPPS, R. L. CARRASQUILLO, and P. WIELAND (NASA, Marshall Space Flight Center, Huntsville, AL) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 15 p. refs
(SAE PAPER 871448)

The current status of the Space Station (SS) Environmental Control and Life Support System (ECLSS) Air Revitalization Subsystem (ARS) design is outlined. ARS performance requirements are provided, along with subsystem options for each ARS function and selected evaluations of the relative merits of each subsystem. Detailed computer models that have been developed to analyze individual subsystem performance capabilities are also discussed. A summary of ARS subsystem level testing planned and completed by NASA Marshall Space Flight Center (MSFC) is given. Author

A88-21110
STATIC FEED ELECTROLYZER TECHNOLOGY ADVANCEMENT FOR SPACE APPLICATION
FRED A. FORTUNATO and KENNETH A. BURKE (Life Systems, Inc., Cleveland, OH) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 15 p.
(SAE PAPER 871450)

NASA's Static Feed Electrolyzer development effort is aimed not only at application in the Space Station Environmental Control/Life Support System, but also its Propulsion and Reboost System, EVA systems, and Electric Power System. The water electrolysis process will generate metabolic oxygen for the crew, and furnish reactants for CO2 removal and reduction, for propulsion/reboost systems, and for fuel cell electric power generation. Attention is presently given to the role of these applications in the design optimization of the electrolyzer, which is envisioned to be based on alkaline chemistry. O.C.

A88-21111* Hamilton Standard, Windsor Locks, Conn.
PERFORMANCE EVALUATION OF SPE ELECTROLYZER FOR SPACE STATION LIFE SUPPORT
A. C. ERICKSON, M. C. PUSKAR, J. A. ZAGAJA (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT), and P. S. MILLER (NASA, Johnson Space Center, Houston, TX) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 8 p.
(SAE PAPER 871451)

An static water-vapor feed electrolyzer has been developed as a candidate for Space Station life-support oxygen generation. The five-cell electrolysis module has eliminated the need for phase separation devices, pumps, and deionizers by transporting only water vapor to the solid polymer electrolyte cells. The introduction of an innovative electrochemical hydrogen pump allows the use of low-pressure reclaimed water to generate gas pressures of up to 230 psia. The electrolyzer has been tested in a computer-controlled test stand featuring continuous, cyclic, and standby operation (including automatic shutdown with fault detection). Author

A88-21112* San Jose State Univ., Calif.
STABILITY OF IRA-45 SOLID AMINE RESIN AS A FUNCTION OF CARBON DIOXIDE ABSORPTION AND STEAM DESORPTION CYCLING
PETER C. WOOD (San Jose State University, CA) and THEODORE WYDEVEN (NASA, Ames Research Center, Moffett Field, CA) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 16 p. refs
(SAE PAPER 871452)

The removal of CO2 from the NASA Space Station's cabin atmosphere, which may be undertaken by a solid-amine water (steam)-desorbed system, is presently evaluated with a view to long-term amine resin stability and adsorption/desorption cycling by means of an automated laboratory flow-testing facility. While the CO2-adsorption capacity of the IRA-45 amine resin used gradually decreased over time, the rate of degradation significantly decreased after the first 10 cycles. Attention is given to the presence (and possible need for removal) of trimethylamine in the process air downstream of the resin bed. O.C.

A88-21113* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
ENVIRONMENTAL CONTROL AND LIFE SUPPORT TESTING AT THE MARSHALL SPACE FLIGHT CENTER
RICHARD G. SCHUNK and WILLIAM R. HUMPHRIES (NASA, Marshall Space Flight Center, Huntsville, AL) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 13 p.
(SAE PAPER 871453)

The Space Station Environmental Control and Life Support System (ECLSS) test program at the Marshall Space Flight Center (MSFC) is addressed. The immediate goals and current activities of the test program are discussed. Also described are the Core Module Integration Facility (CMIF) and the initial ECLSS test configuration. Future plans for the ECLSS test program and the CMIF are summarized. Author

A88-21114
INITIAL RESULTS OF INTEGRATED TESTING OF A REGENERATIVE ECLSS AT MSFC
JOHN K. JACKSON, EDSON A. WORDEN (Boeing Aerospace Co., Seattle, WA), ROBERT B. BOYDA (Life Systems, Inc., Cleveland, OH), and RICHARD L. JOHNSON (AiResearch Manufacturing Co., Torrance, CA) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 12 p.
(SAE PAPER 871454)

The environmental control and life support system (ECLSS) presently discussed encompasses a four-bed molecular sieve, a static-feed water electrolysis subsystem, and a urine pretreatment mixing unit. These subsystems are undergoing independent tests, upon whose completion 'open door' integrated system tests will be conducted to demonstrate suitability. These will lead to 'closed door' ECLSS testing to verify system operation over a range of imposed metabolic loads, ambient temperatures, and relative humidities for durations of 30 or more days. O.C.

A88-21115* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
TECHNOLOGY DEMONSTRATOR PROGRAM FOR SPACE STATION ENVIRONMENTAL CONTROL LIFE SUPPORT SYSTEM
ALAN M. ADAMS, GORDON K. PLATT, WILLIAM C. CLAUNCH, and WILLIAM R. HUMPHRIES (NASA, Marshall Space Flight Center, Huntsville, AL) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 7 p.
(SAE PAPER 871456)

The main objectives and requirements of the NASA/Marshall Space Flight Center Technology Demonstration Program are discussed. The program consists of a comparative test and a 90-day manned system test to evaluate an Environmental Control and Life Support System (ECLSS). In the comparative test phase, 14 types of subsystems which perform oxygen and water reclamation functions are to be examined in terms of performance maintenance/service requirements, reliability, and safety. The manned chamber testing phase involves a four person crew using a partial ECLSS for 90 days. The schedule for the program and the program hardware requirements are described. I.F.

A88-21125* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
WATER MANAGEMENT REQUIREMENTS FOR ANIMAL AND PLANT MAINTENANCE ON THE SPACE STATION
C. C. JOHNSON, D. RASMUSSEN (NASA, Ames Research Center, Moffett Field, CA), and G. CURRAN (Bionetics Corp., Moffett Field, CA) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 9 p. refs
(SAE PAPER 871469)

Long-duration Space Station experiments that use animals and plants as test specimens will require increased automation and advanced technologies for water management in order to free scientist-astronauts from routine but time-consuming housekeeping tasks. The three areas that have been identified as requiring water management and that are discusseed are: (1) drinking water and humidity condensate of the animals, (2) nutrient solution and transpired water of the plants, and (3) habitat cleaning methods. Automation potential, technology assessment, crew time savings, and resupply penalties are also discussed. Author

A88-21126* Life Systems, Inc., Cleveland, Ohio.
ELECTROCHEMICALLY REGENERABLE CARBON DIOXIDE/MOISTURE CONTROL TECHNOLOGY FOR AN ADVANCED EXTRAVEHICULAR MOBILITY UNIT
M. C. LEE, M. SUDAR (Life Systems, Inc., Cleveland, OH), and R. J. CUSICK (NASA, Johnson Space Center, Houston, TX) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 12 p. refs
(Contract NAS9-17307)
(SAE PAPER 871470)

Regenerable CO2/moisture removal techniques that reduce the expendables and logistics requirements are needed to sustain people undertaking EVAs for the Space Station. Here, the development of electrochemically regenerable CO2 absorption (ERCA) technology to replace the nonregenerable LiOH absorber for the advanced Portable Life Support System (PLSS) is reported. During EVA the ERCA uses a mechanism involving gas absorption into a liquid absorbent for the removal and storage of the metabolically produced CO2 and moisture. Following the EVA, the expended absorbent is regenerated onboard the Space Station by an electrochemical CO2 concentrator. The ERCA concept has the ability to effectively satisfy the high metabolic CO2 and moisture removal requirements of PLSS applications. This paper defines the ERCA concept and its advantages for the PLSS application, reviews breadboard test data, and presents physical characteristics of the breadboard and projected flight hardware. Author

A88-21127* Hamilton Standard Div., United Aircraft Corp., Windsor Locks, Conn.
DEVELOPMENT OF A REGENERABLE HUMIDITY AND CO2 CONTROL SYSTEM FOR AN ADVANCED EMU
TIMOTHY A. NALETTE (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) and ROBERT J. CUSICK (NASA, Johnson Space Center, Houston, TX) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 10 p. refs
(SAE PAPER 871471)

A 5-h-regenerable nonventing humidity and CO2 control subsystem (HCCS) technology demonstration unit is being developed for potential use in an Advanced Extravehicular Mobility Unit for Space Station application. The HCCS incorporates a weak-base-anion exchange resin packed in a metal-foam-matrix heat exchanger. This system simultaneously removes CO2 and water vapor, with the resulting exothermic heat of reaction rejected to the heat exchanger. The system has no moving parts, resulting in a highly reliable simple configuration. Regeneration may be accomplished via internal heating and vacuum. Author

A88-21128
HIGH PRESSURE WATER ELECTROLYSIS FOR THE SPACE STATION
JOHN R. NASON and PAUL G. TREMBLAY (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 11 p. refs
(SAE PAPER 871473)

The benefits and penalties associated with the generation of high pressure gases using the SPE water electrolysis subsystem are presented. The Space Station has a number of requirements for oxygen and hydrogen generation at very high pressures (between 1000 and 6000 psia) including emergency pressurization and repressurization of habitability and laboratory modules, recharge of the Extravehicular Mobility Unit (EMU) oxygen tanks, and propulsion capability for Station reboost and attitude control. The traditional trade study parameters of weight, volume, power, and heat rejection are considered. The ramifications of the use of a high pressure, solid polymer electrolyte-based system are discussed with respect to Space Station safety and maintenance. Author

A88-21141
SPACECRAFT WATER SYSTEM DISINFECTION TECHNOLOGY - PAST, PRESENT, AND FUTURE NEEDS
CHARLES E. WILLIS and JOHN R. SCHULTZ (KRUG International, Houston, TX) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 11 p. refs
(SAE PAPER 871487)

The possibility of microbial contamination and spread in spacecraft water systems during long-duration missions calls for initial system disinfection, initial water supply disinfection, and maintenance of disinfection throughout the water distribution system. Attention must also be given to episodic system disinfection capabilities [illegible] isolation of the water supply from any back-contamination or cross-contamination. Especially severe

design criteria must be met in all these cases by the closed recycling systems envisioned for such long duration space missions as those of the NASA Space Station. O.C.

A88-21142* Umpqua Research Co., Myrtle Creek, Ore.
REVIEW OF WATER DISINFECTION TECHNIQUES
GERALD V. COLOMBO (Umpqua Research Co., Myrtle Creek, OR) and RICHARD L. SAUER (NASA, Johnson Space Center, Houston, TX) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 7 p. refs
(SAE PAPER 871488)

Throughout the history of manned space flight the supply of potable water to the astronauts has presented unique problems. Of particular concern has been the microbiological quality of the potable water. This has required the development of both preflight water system servicing procedures to disinfect the systems and inflight disinfectant addition and monitoring devices to ensure continuing microbiological control. The disinfectants successfully used to date have been aqueous chlorine or iodine. Because of special system limitations the use of iodine has been the most successful for inflight use and promises to be the agent most likely to be used in the future. Future spacecraft potable, hygiene, and experiment water systems will utilize recycled water. This will present special problems for water quality control. NASA is currently conducting research and development to solve these problems. Author

A88-21143* Montana State Univ., Bozeman.
CONSEQUENCES OF BACTERIAL RESISTANCE TO DISINFECTION BY IODINE IN POTABLE WATER
GORDON A. MCFETERS and BARRY H. PYLE (Montana State University, Bozeman) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 16 p. refs
(Contract NAS9-17346)
(SAE PAPER 871489)

This study was done to quantify the sensitivity of bacteria to iodine under controlled laboratory conditions. When exposed to 1 mg/1 I2 for 1 min, bacteria isolated from the Shuttle were more resistant than a P. aeruginosa isolated from a povidine-iodine solution. Cultures grown in rich media were more sensitive than those grown in low nutrient solutions. The P. aeruginosa and a P. cepacia isolated from the Shuttle were resuspended in PBW after exposure to iodine. Iodinated cells recovered better than uniodinated controls. Pseudomonads in biofilms developed on coupons of stainless steel were more resistant to iodine than cells suspended in buffered water. Although resistant bacteria may colonize spacecraft water systems, multiple treatment barriers should provide adequate control of these contaminants. Author

A88-21145
TOXICOLOGICAL ASPECTS OF WATER RECYCLE AND DISINFECTION
RICHARD J. BULL (Washington State University, Pullman) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 9 p. refs
(SAE PAPER 871491)

Two sources of toxic chemicals are readily recognized in recycling wastewater for potable purposes: those introduced by the prior use of the water and those introduced during treatment and distribution of the water. Historically, the focus in water treatment has been directed towards the former source and with little attention being paid to the latter. In a system with a source that is made up of primarily domestic types of waste, the production of by-products with treatment chemicals and the leaching of materials from surfaces that contact potable water are important sources of toxic chemicals. The most instructive example involves by-products generated during disinfection. A system such as that contemplated for the Space Station may well magnify these problems unless the treatment is designed to prevent chemicals from these sources from accumulating in the water system. The present paper focuses on the genesis of these problems and the toxicological hazards that result. Author

A88-21146* State Univ. of New York, Binghamton.
TREATMENT BED MICROBIOLOGICAL CONTROL
GILBERT E. JANAUER, TIMOTHY W. FITZPATRICK, MICHAEL B. KRIL, GEORGIA A. WILBER (New York, State University, Binghamton), and RICHARD L. SAUER (NASA, Johnson Space Center, Houston, TX) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 18 p. refs
(Contract NAS9-11604)
(SAE PAPER 871492)

The effects of microbial fouling on treatment bed (TB) performance are being studied. Fouling of activated carbon (AC) and ion exchange resins (IEX) by live and devitalized bacteria can cause decreased capacity for selected sorbates with AC and IEX TB. More data are needed on organic species removal in the trace region of solute sorption isotherms. TB colonization was prevented by nonclassical chemical disinfectant compositions (quaternary ammonium resins) applied in suitable configurations. Recently, the protection of carbon beds via direct disinfectant impregnation has shown promise. Effects (of impregnation) upon bed sorption/removal characteristics are to be studied with representative contaminants. The potential need to remove solutes added or produced during water disinfection and/or TB microbiological control must be investigated. Author

A88-21147* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
INFLIGHT MICROBIAL ANALYSIS TECHNOLOGY
DUANE L. PIERSON (NASA, Johnson Space Center, Houston, TX) and HARLAN D. BROWN (KRUG International, Technology Life Sciences Div., Houston, TX) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 5 p.
(SAE PAPER 871493)

This paper provides an assessment of functional characteristics needed in the microbial water analysis system being developed for Space Station. Available technology is reviewed with respect to performing microbial monitoring, isolation, or identification functions. An integrated system composed of three different technologies is presented. Author

A88-21156* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
STATUS OF THE SPACE STATION WATER RECLAMATION AND MANAGEMENT SUBSYSTEM DESIGN CONCEPT
R. M. BAGDIGIAN and P. L. MORTAZAVI (NASA, Marshall Space Flight Center, Huntsville, AL) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 11 p. refs
(SAE PAPER 871510)

A development status report is presented for the NASA Space Station's water reclamation and management (WRM) system, for which the candidate phase change-employing processing technologies are an air evaporation subsystem, a thermoelectric integrated membrane evaporation subsystem, and the vapor compression distillation subsystem. These WRM candidates employ evaporation to effect water removal from contaminants, but differ in their control of the vapor/liquid interface in zero-gravity and in the recovery of the latent heat of vaporization. O.C.

A88-21158* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
TEST RESULTS OF A SHOWER WATER RECOVERY SYSTEM
CHARLES E. VEROSTKO, DONALD F. PRICE, RAFAEL GARCIA, DUANE L. PIERSON, RICHARD L. SAUER (NASA, Johnson Space Center, Houston, TX) et al. SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 16 p. refs
(SAE PAPER 871512)

A shower test was conducted recently at NASA-JSC in which waste water was reclaimed and reused. Test subjects showered in a prototype whole body shower following a protocol similar to that anticipated for Space Station. The waste water was purified

using reverse osmosis followed by filtration through activated carbon and ion exchange resin beds. The reclaimed waste water was maintained free of microorganisms by using both heat and iodine. This paper discusses the test results, including the limited effectiveness of using iodine as a disinfectant and the evaluation of a Space Station candidate soap for showering. In addition, results are presented on chemical and microbial impurity content of water samples obtained from various locations in the water recovery process. Author

A88-21159
DEVELOPMENT OF A NON-PHASE-CHANGE WASTE-WATER TREATMENT SUBSYSTEM
S. B. MCCRAY, R. J. RAY, C. A. THORNTON, D. D. NEWBOLD (Bend Research, Inc., OR), and H. H. PETERS (Boeing Aerospace Co., Seattle, WA) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 19 p. refs
(SAE PAPER 871514)

This paper describes the continued development of a non-phase-change waste-water subsystem for use in the planned manned Space Station. Comparisons of various membrane-based technologies when operated side by side on feed solutions of synthetic wash water are presented. The effects of soap type and operating temperature on membrane-module performance were determined. A preliminary ranking of these modules indicated that several of the reverse-osmosis and ultrafiltration technologies are excellent candidates for use in the subsystem. At this time, a hybrid system configuration consisting of a first-stage ultrafiltration module followed by a second-stage reverse-osmosis module appears to be the most appropriate for use in the subsystem. Author

A88-21161
EXPERIMENTAL STUDY FOR CARBON DIOXIDE REMOVAL SYSTEM IN SPACE STATION
T. ETOH, T. NIHEI, K. OTSUJI, S. SATOH, and S. HATANO (Mitsubishi Heavy Industries, Ltd., Tokyo, Japan) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 9 p.
(SAE PAPER 871516)

As the result of the human metabolism in the Space Station, carbon dioxide is discharged into the cabin atmosphere. It is indispensable to remove the carbon dioxide and keep it below the allowable level for life support in a closed environment. The regenerative carbon dioxide removal system is necessary for the Space Station to decrease the life-cycle cost. The Solid Amine Water Desorbed (SAWD) system is considered as a competitive option among several candidate systems. In the SAWD process, the carbon dioxide gas is adsorbed by the ion-exchange-type solid amine, which is bedded in the canisters, and desorbed by heating the solid amine with the direct steam flow. The adsorption and desorption stage of the canisters are proceeded alternatively by the automatic control. For the application in the Space Station, the SAWD system shall embody less resources as well as high performance and reliability. Author

A88-21162
AN EXPERIMENTAL STUDY OF THE BOSCH AND THE SABATIER CO2 REDUCTION PROCESSES
K. OTSUJI, O. HANABUSA, T. SAWADA, S. SATOH, and M. MINEMOTO (Mitsubishi Heavy Industries, Ltd., Tokyo, Japan) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 8 p.
(SAE PAPER 871517)

An experimental comparison has been conducted in order to evaluate the relative merits of the Bosch and Sabatier systems for CO2 cracking and oxygen recovery, with a view to the obviation of consummable supply requirements in long duration manned space missions. The test data evaluation has given attention to the most equitable basis for CO2 cracking process comparison, the system configurations of the two processes, their reduction efficiency, their energy requirements, and their course of product carbon treatment. The preliminary results obtained favor the Sabatier reaction, in virtue of its high productivity and dense carbon deposition. O.C.

A88-21164
DESIGN AND DEVELOPMENT OF THE LIFE SUPPORT SUBSYSTEM OF A LABORATORY MODEL OF THE BOTANY FACILITY
W. P. FOTH and H. LOESER (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 13 p. ESA-supported research.
(SAE PAPER 871519)

For botanical experiments of long duration (e.g., Eureca Botany Facility) the life support subsystem has to provide the composition of the atmosphere as far as the CO2 and O2 partial pressure and total pressure are concerned. Furthermore, the air humidity and the soil moisture has to be controlled. In order to allow the potential experimenters to gain practical experience in growing plant samples in such an environment and to learn how selected plants react to various operational conditions, a laboratory model has been designed and tested. Author

A88-21635
USE OF COMMUNICATING EXPERT SYSTEMS IN FAULT DIAGNOSIS FOR SPACE STATION APPLICATIONS
J. Y. READ, T. P. HOWLAND, and W. A. PERKINS (Lockheed Research Laboratories, Palo Alto, CA) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 30-39. refs

A communicating expert system for fault diagnosis and fault correction has been developed in a prototype for the Space Station Air Revitalization System. The system consists of three communicating expert systems, one for oxygen generation, one for CO2 removal, and a supervisor for overall control. The three system modules communicate via mailboxes. The problems and advantages of using such a communicating expert system framework are discussed. C.D.

A88-29136
THE FEASIBILITY OF CHLORELLA AS THE EXCHANGER OF CO2 FOR O2 AND THE FOOD RESOURCES IN THE SPACE STATION
TATSUICHI IWAMURA (Nagoya University, Japan) IN: Biological sciences in space 1986; Proceedings of the 1986 International Symposium, Nagoya, Japan, Nov. 10-12, 1986. Tokyo, MYU Research, 1987, p. 257-264. refs

The feasibility of Chlorella as the exchanger of CO2 for O2 and the nutritional food resources in the Space Station is estimated by calculating the oxygen production from the growing algal cells in a continuous culture system where the cell population density and other environmental conditions are kept constant. An algal culture placed on a hemispheric surface of about 2-3 m in radius is needed to generate the oxygen and nutritional biomass necessary for human activity on the Space Station. Problems associated with the construction of the algal culture system and the utilization of the algal biomass as food and feed are discussed. K.K.

A88-31398*# Southwest Research Inst., San Antonio, Tex.
LONG-LIFE ASSURANCE FOR SPACE STATION - IS IT AN ISSUE?
T. A. CRUSE, C. H. PARR (Southwest Research Institute, San Antonio, TX), L. J. LEGER, and O. E. PIGG (NASA, Johnson Space Center, Houston, TX) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 179-186. refs
(Contract NCC9-17)
(AIAA PAPER 88-2489)

Various issues related to the long-life assurance (LLA) of the Space Station (SS) are discussed. The effects of exposure to atomic oxygen, radiation, thermal cycling, micrometeoroid and

debris damage, and the physical aging of polymers on the SS materials are examined. The proper design of the SS truss system and pressure vessels, electronic systems, mechanical systems, and software for LLA is addressed. C.D.

N88-10491*# Signal Research Center, Inc., Des Plaines, Ill.
CATALYTIC PROCESSES FOR SPACE STATION WASTE CONVERSION Final Report, 1 Oct. 1985 - 31 Jul. 1986
M. W. SCHOONOVER and R. A. MADSEN (AiResearch Mfg. Co., Torrance, Calif.) Jul. 1986 43 p
(Contract NAS2-12265)
(NASA-CR-177423; NAS 1.26:177423) Avail: NTIS HC A03/MF A01 CSCL 06K

Catalytic techniques for processing waste products onboard space vehicles were evaluated. The goal of the study was the conversion of waste to carbon, wash water, oxygen and nitrogen. However, the ultimate goal is conversion to plant nutrients and other materials useful in closure of an ecological life support system for extended planetary missions. The resulting process studied involves hydrolysis at 250 C and 600 psia to break down and compact cellulose material, distillation at 100 C to remove water, coking at 450 C and atmospheric pressure, and catalytic oxidation at 450 to 600 C and atmospheric pressure. Tests were conducted with a model waste to characterize the hydrolysis and coking processes. An oxidizer reactor was sized based on automotive catalytic conversion experience. Products obtained from the hydrolysis and coking steps included a solid residue, gases, water condensate streams, and a volatile coker oil. Based on the data obtained, sufficient component sizing was performed to make a preliminary comparison of the catalytic technique with oxidation for processing waste for a six-man spacecraft. Wet oxidation seems to be the preferred technique from the standpoint of both component simplicity and power consumption. Author

N88-10848*# Tennessee Technological Univ., Cookeville.
RAPID TOXICITY DETECTION IN WATER QUALITY CONTROL UTILIZING AUTOMATED MULTISPECIES BIOMONITORING FOR PERMANENT SPACE STATIONS
E. L. MORGAN, R. C. YOUNG, M. D. SMITH (Tennessee Valley Authority, Knoxville.), and K. W. EAGLESON *In* NASA- Goddard Space Flight Center, Greenbelt, Md. Fourteenth Space Simulation Conference: Testing for a Permanent Presence in Space p 227-235 1986
Avail: NTIS HC A19/MF A01 CSCL 06B

The objective of this study was to evaluate proposed design characteristics and applications of automated biomonitoring devices for real-time toxicity detection in water quality control on-board permanent space stations. Simulated tests in downlinking transmissions of automated biomonitoring data to Earth-receiving stations were simulated using satellite data transmissions from remote Earth-based stations. Author

N88-12252*# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
PROGRESS IN EUROPEAN CELSS ACTIVITIES
A. I. SKOOG *In* NASA, Ames Research Center, Controlled Ecological Life Support System: Regenerative Life Support Systems in Space p 1-4 Sep. 1987
Avail: NTIS HC A08/MF A01 CSCL 06K

The European Controlled Ecological Life Support System (CELSS) activities started in the late 1970's with system analysis and feasibility studies of Biological Life Support Systems (BLSS). The initiation for CELSS came from the industry side in Europe, but since then planning and hardware feasibility analyses have been initiated also from customer/agency side. Despite this, it is still too early to state that a CELSS program as a concerted effort has been agreed upon in Europe. However, the general CELSS objectives were accepted as planning and possible development goals for the European effort for manned space activities, and as experimental planning topics in the life sciences community for the next decades. It is expected that ecological life support systems can be tested and implemented on a space station towards the end of this century or early in the next. For the European activities a possible scenario can be projected based on ongoing life support system development activities and the present life sciences goals. Author

N88-12258*# Keio Univ., Yokahama (Japan).
SUNLIGHT SUPPLY AND GAS EXCHANGE SYSTEMS IN MICROALGAL BIOREACTOR
K. MORI, H. OHYA, K. MATSUMOTO, and H. FURUNE (La Foret Engineering and Information Service Co., Tokyo, Japan) *In* NASA, Ames Research Center, Controlled Ecological Life Support System: Regenerative Life Support Systems in Space p 45-50 Sep. 1987
Avail: NTIS HC A08/MF A01 CSCL 06K

The bioreactor with sunlight supply system and gas exchange systems presented has proved feasible in ground tests and shows much promise for space use as a closed ecological life support system device. The chief conclusions concerning the specification of total system needed for a life support system for a man in a space station are the following: (1) Sunlight supply system - compactness and low electrical consumption; (2) Bioreactor system - high density and growth rate of chlorella; and (3) Gas exchange system - enough for O2 production and CO2 assimilation. Author

N88-12267*# National Aerospace Lab., Tokyo (Japan). Space Technology Research Group.
AN OVERVIEW OF JAPANESE CELSS RESEARCH ACTIVITIES
KEIJI NITTA *In* NASA, Ames Research Center, Controlled Ecological Life Support System: Regenerative Life Support Systems in Space p 93-101 Sep. 1987
Avail: NTIS HC A08/MF A01 CSCL 06K

Development of Controlled Ecological Life Support System (CELSS) technology is inevitable for future long duration stays of human beings in space, for lunar base construction and for manned Mars flight programs. CELSS functions can be divided into 2 categories, Environmental Control and Material Recycling. Temperature, humidity, total atmospheric pressure and partial pressure of oxygen and carbon dioxide, necessary for all living things, are to be controlled by the environment control function. This function can be performed by technologies already developed and used as the Environment Control Life Support System (ECLSS) of Space Shuttle and Space Station. As for material recycling, matured technologies have not yet been established for fully satisfying the specific metabolic requirements of each living thing including human beings. Therefore, research activities for establishing CELSS technology should be focused on material recycling technologies using biological systems such as plants and animals and physico-chemical systems, for example, a gas recycling system, a water purifying and recycling system and a waste management system. Japanese research activities were conducted and will be continued accordingly. Author

N88-14625*# Boeing Aerospace Co., Seattle, Wash.
CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEMS (CELSS) CONCEPTUAL DESIGN OPTION STUDY
MELVIN OLESON and RICHARD L. OLSON Jun. 1986 171 p
(Contract NAS2-11806)
(NASA-CR-177421; NAS 1.26:177421) Avail: NTIS HC A08/MF A01 CSCL 06K

Results are given of a study to explore options for the development of a Controlled Ecological Life Support System (CELSS) for a future Space Station. In addition, study results will benefit the design of other facilities such as the Life Sciences Research Facility, a ground-based CELSS demonstrator, and will be useful in planning longer range missions such as a lunar base or manned Mars mission. The objectives were to develop weight and cost estimates for one CELSS module selected from a set of preliminary plant growth unit (PGU) design options. Eleven Space Station CELSS module conceptual PGU designs were reviewed, components and subsystems identified and a sensitivity analysis performed. Areas where insufficient data is available were identified and divided into the categories of biological research, engineering

research, and technology development. Topics which receive significant attention are lighting systems for the PGU, the use of automation within the CELSS system, and electric power requirements. Other areas examined include plant harvesting and processing, crop mix analysis, air circulation and atmosphere contaminant flow subsystems, thermal control considerations, utility routing including accessibility and maintenance, and nutrient subsystem design. Author

N88-14826*# Boeing Aerospace Co., Seattle, Wash.
CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEMS (CELSS) PHYSIOCHEMICAL WASTE MANAGEMENT SYSTEMS EVALUATION
M. OLESON, T. SLAVIN, F. LIENING, and R. L. OLSON Jun. 1986 146 p
(Contract NAS2-11806)
(NASA-CR-177422; NAS 1.26:177422; BAC-37) Avail: NTIS HC A07/MF A01 CSCL 06K

Parametric data for six waste management subsystems considered for use on the Space Station are compared, i.e.: (1) dry incineration; (2) wet oxidation; (3) supercritical water oxidation; (4) vapor compression distillation; (5) thermoelectric integrated membrane evaporation system; and (6) vapor phase catalytic ammonia removal. The parameters selected for comparison are on-orbit weight and volume, resupply and return to Earth logistics, power consumption, and heat rejection. Trades studies are performed on subsystem parameters derived from the most recent literature. The Boeing Engineering Trade Study (BETS), an environmental control and life support system (ECLSS) trade study computer program developed by Boeing Aerospace Company, is used to properly size the subsystems under study. The six waste treatment subsystems modeled in this program are sized to process the wastes for a 90-day Space Station mission with an 8-person crew, and an emergency supply period of 28 days. The resulting subsystem parameters are compared not only on an individual subsystem level but also as part of an integrated ECLSS. Author

N88-14856*# Texas A&M Univ., College Station. Dept. of Home Economics.
THE DETERMINATION OF NUTRITIONAL REQUIREMENTS FOR SAFE HAVEN FOOD SUPPLY SYSTEM (EMERGENCY/SURVIVAL FOOCS) Final Report
SELINA AHMED *In* NASA. Lyndon B. Johnson Space Center, Houston, Tex. NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 1 18 p Nov. 1987
Avail: NTIS HC A15/MF A01 CSCL 06H

The Space Station Safe Haven Food System must sustain 8 crew members under emergency conditions for 45 days. Emergency Survival Foods are defined as a nutritionally balanced collection of high density food and beverages selected to provide for the survival of Space Station flight crews in contingency situations. Since storage volume is limited, the foods should be highly concentrated. A careful study of different research findings regarding starvation and calorie restricted diets indicates that a minimum nutritional need close to RDA is an important factor for sustaining an individual's life in a stressful environment. Fat, protein, and carbohydrates are 3 energy producing nutrients which play a vital role in the growth and maintenance process of human life. A lower intake of protein can minimize the water intake, but it causes a negative nitrogen balance and a lower performance level. Other macro and micro nutrients are also required for nutritional interrelationships to metabolize the other 3 nutrients to their optimum level. The various options for longer duration than 45 days are under investigation. Author

N88-14858*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
PERFORMANCE CONSIDERATIONS FOR THE ASTROMETRIC TELESCOPE FACILITY ON THE PHASE 1 SPACE STATION
KENJI NISHIOKA, GEORGE D. GATEWOOD (Pittsburgh Univ., Pa.), ALFRED C. MACSY, CHARLES K. SOBECK, and JOEL SPERANS Dec. 1987 12 p
(NASA-TM-100040; A-88021; NAS 1.15:100040) Avail: NTIS HC A03/MF A01 CSCL 03A

The Astrometric Telescope Facility (ATF) is an optical telescope facility of extreme astrometric precision whose principle scientific purpose is the detection and study of planetary systems about nearby stars. With the recent change in the space station program to two phases, the suitability of initial operations from the phase 1 station need to be evaluated. This paper presents the results of such an evaluation for the Astrometric Telescope Facility. Author

N88-16376*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
MONITORING OF SPACE STATION LIFE SUPPORT SYSTEMS WITH MINIATURE MASS SPECTROMETRY AND ARTIFICIAL INTELLIGENCE Abstract Only
RICHARD A. YOST, JODIE V. JOHNSON (Florida State Univ., Gainesville.), and CARLA M. WONG *In* NASA. Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 1 p 87 Nov. 1987
Avail: NTIS HC A18/MF A01 CSCL 09B

The combination of quadrupole ion trap tandem mass spectroscopy with artificial intelligence is a promising approach for monitoring the performance of the life support systems in the space station. Such an analytical system can provide the selectivity, sensitivity, speed, small size, and decision making intelligence to detect, identify, and quantify trace toxic compounds which may accumulate in the space station habitat. Author

N88-16442*# Honeywell, Inc., Clearwater, Fla. Space and Strategic Avionics Div
PROTOTYPE SPACE STATION AUTOMATION SYSTEM DELIVERED AND DEMONSTRATED AT NASA
ROGER F. BLOCK *In* NASA. Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 1 p 447-451 Nov. 1987
Avail: NTIS HC A18/MF A01 CSCL 09B

The Automated Subsystem Control for Life Support System (ASCLSS) program has successfully developed and demonstrated a generic approach to the automation and control of Space Station subsystems. The hierarchical and distributed real time controls system places the required controls authority at every level of the automation system architecture. As a demonstration of the automation technique, the ASCLSS system automated the Air Revitalization Group (ARG) of the Space Station regenerative Environmental Control and Life Support System (ECLSS) using real-time, high fidelity simulators of the ARG processes. This automation system represents an early flight prototype and an important test bed for evaluating Space Station controls technology including future application of ADA software in real-time control and the development and demonstration of embedded artificial intelligence and expert systems (AI/ES) in distributed automation and controls systems. Author

N88-17179*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DESIGN CONCEPTS FOR BIOREACTORS IN SPACE
P. K. SESHAN, G. R. PETERSON, B. BEARD, C. BOSHE, and E. H. DUNLOP (Washington Univ., Seattle.) *In* NASA. Lyndon B. Johnson Space Center, Space Bioreactor Science Workshop p 147-159 Dec. 1987 Previously announced as N86-19926
Avail: NTIS HC A09/MF A01 CSCL 06B

Microbial food sources are becoming viable and more efficient alternatives to conventional food sources, especially in the context of closed ecological life support systems (CELSS) in space habitats. Two bioreactor design concepts presented represent two dissimilar approaches to grappling with the absence of gravity in space habitats and deserve to be tested for adoption as important components of the life support function aboard spacecraft, space stations and other extra-terrestrial habitats. R.J.F.

N88-17722*# Boeing Aerospace Co., Seattle, Wash.
SYSTEM ANALYSIS STUDY OF SPACE PLATFORM AND STATION ACCOMMODATIONS FOR LIFE SCIENCES RESEARCH FACILITIES. VOLUME 2: STUDY RESULTS, ATTACHMENT 2. PHASE A: CONCEPTUAL DESIGN AND PROGRAMMATICS Final Report
LOWELL F. WILEY Oct. 1985 107 p
(Contract NAS8-35471)
(NASA-CR-179272; NAS 1.26:179272; D180-27863-2-VOL-2; DPD-614-VOL-2; DR-5-VOL-2) Avail: NTIS HC A06/MF A01 CSCL 22B

The study results from the conceptual design and programmatics segment of the Space Platform and Station Accommodation for Life Sciences Research Facilities. The results and significant findings of the conceptual design and programmatics were generated by these tasks: (1) the review and update engineering and science requirements; (2) analysis of life sciences mission transition scenario; (3) the review and update of key trade issues; (4) the development of conceptual definition and designs; and (5) the development of the work breakdown schedule and its dictionary, program schedule, and estimated costs. Author

N88-17723*# Boeing Aerospace Co., Seattle, Wash.
SYSTEM ANALYSIS STUDY OF SPACE PLATFORM AND STATION ACCOMMODATIONS FOR LIFE SCIENCES RESEARCH FACILITIES. VOLUME 2: STUDY RESULTS. APPENDIX E: WORK BREAKDOWN STRUCTURE AND DICTIONARY Final Report
LOWELL F. WILEY Oct. 1985 115 p
(Contract NAS8-35471)
(NASA-CR-179274; NAS 1.26:179274; D180-27863-2-VOL-2-APP-E; DPD-614-VOL-2-APP-E; DR-4-VOL-2-APP-E) Avail: NTIS HC A06/MF A01 CSCL 22B

A work breakdown structure for the Space Station Life Sciences Research Facility (LSRF) is presented up to level 5. The purpose is to provide the framework for task planning and control and to serve as a basis for budgeting, task assignment, cost collection and report, and contractual performance measurement and tracking of the Full Scale Development Phase tasks. J.P.B.

N88-17724*# Boeing Aerospace Co., Seattle, Wash.
SYSTEM ANALYSIS STUDY OF SPACE PLATFORM AND STATION ACCOMMODATIONS FOR LIFE SCIENCES RESEARCH FACILITIES. VOLUME 2: STUDY RESULTS. APPENDIX D: LIFE SCIENCES RESEARCH FACILITY REQUIREMENTS Final Report
LOWELL F. WILEY Oct. 1985 46 p
(Contract NAS8-35471)
(NASA-CR-179273; NAS 1.26:179273; D180-27863-2-VOL-2-APP-D; DPD-614-VOL-2-APP-D; DR-4-VOL-2-APP-D) Avail: NTIS HC A03/MF A01 CSCL 22B

The purpose of this requirements document is to develop the foundation for concept development for the Life Sciences Research Facility (LSRF) on the Space Station. These requirements are developed from the perspective of a Space Station laboratory module outfitter. Science and mission requirements including those related to specimens are set forth. System requirements, including those for support, are detailed. Functional and design requirements are covered in the areas of structures, mechanisms, electrical power, thermal systems, data management system, life support, and habitability. Finally, interface requirements for the Command Module and Logistics Module are described. J.P.B.

N88-19080# Joint Publications Research Service, Arlington, Va.
BALLISTOCARDIOGRAPHY IN WEIGHTLESSNESS RESEARCH Abstract Only
R. M. BAYEVSKIY, I. I. FUNTOVA, and M. D. ZAKATOV *In its* JPRS Report: Science and Technology. USSR: Life Sciences p 1 12 Feb. 1988 Transl. into ENGLISH from Vestnik Akademii Meditsinskikh Nauk SSSR (Moscow, USSR), no. 6, Jun. 1987 p 77-84
Avail: NTIS HC A04/MF A01

A review is presented of advances in ballistocardiographic studies during weightlessness aboard Salyut-6 and -7 space ships, as well as in controlled ground experimentation. The latter involved ten 19 to 20-year-old males subjected to antiorthostatic kinesia for prolonged periods of time to simulate weightlessness. In general, the results of both series were in agreement. Over a 90-day period three basic phases of changes in cardiac contractility were identified. The initial stage was a diminished mechanical activity of the right heart. The second stage consisted of enhanced contractility of the right ventricle with simultaneous reduction in the contractility of the left heart. The final stage was a reversal of the phenomenon in the second stage, i.e., enhanced contractility of the left ventricle with concomitant reduction in contractility of the right heart. Further developments in ballistocardiographic techniques and equipment will lead to an expanded use of this technology in clinical medicine, following its initial development for space physiology. Author

N88-19567*# Lockheed Missiles and Space Co., Sunnyvale, Calif. Space Station Bioastronautics Group.
CONCEPTUAL DESIGN AND PROGRAMMATICS STUDIES OF SPACE STATION ACCOMMODATIONS FOR LIFE SCIENCES RESEARCH FACILITIES (LSRF) Final Review Document
1 Nov. 1985 210 p
(Contract NAS8-35472)
(NASA-CR-179270; NAS 1.26:179270; LMSC/D071217; DR-3) Avail: NTIS HC A10/MF A01 CSCL 22B

Conceptual designs and programmatics of the space station accommodations for the Life Sciences Research Facilities (LSRF) are presented. The animal ECLSS system for the LSRF provides temperature-humidity control, air circulation, and life support functions for experimental subjects. Three ECLSS were studied. All configurations presented satisfy the science requirements for: animal holding facilities with biosolation; facilities interchangeable to hold rodents, small primates, and plants; metabolic cages interchangeable with standard holding cages; holding facilities adaptable to restrained large primates and rodent breeding/nesting cages; volume for the specified instruments; enclosed germ-free workbench for manipulation of animals and chemical procedures; freezers for specimen storage until return; and centrifuge to maintain animals and plants at fractional g to 1 g or more, with potential for accommodating humans for short time intervals. B.G.

N88-19888*# California Univ., Berkeley. Dept. of Architecture.
SOCIAL FACTORS IN SPACE STATION INTERIORS
GALEN CRANZ, ALICE EICHOLD, KLAUS HOTTES, KEVIN JONES, and LINDA WEINSTEIN *In* NASA, Ames Research Center, Space Station Human Factors Research Review. Volume 3: Space Station Habitability and Function: Architectural Research p 165-190 Oct. 1987
Avail: NTIS HC A10/MF A01 CSCL 05H

Using the example of the chair, which is often written into space station planning but which serves no non-cultural function in zero gravity, difficulties in overcoming cultural assumptions are discussed. An experimental approach is called for which would allow designers to separate cultural assumptions from logistic, social and psychological necessities. Simulations, systematic doubt and monitored brainstorming are recommended as part of basic research so that the designer will approach the problems of space module design with a complete program. J.P.B.

06

DYNAMICS AND CONTROLS

Includes descriptions of analytical techniques and computer codes, trade studies, requirements and descriptions of orbit maintenance systems, rigid and flexible body attitude sensing systems and controls such as momentum wheels and/or propulsive schemes.

A88-10050
THEORETICAL PRINCIPLES OF THE OPTIMAL CONTROL OF FLEXIBLE SPACECRAFT [TEORETICHESKIE OSNOVY OPTIMAL'NOGO UPRAVLENIIA UPRUGIMI KOSMICHESKIMI APPARATAMI]
GENNADII LUKICH DEGTIAREV and TALGAT KASIMOVICH SIRAZETDINOV Moscow, Izdatel'stvo Mashinostroenie, 1986, 216 p. In Russian. refs

The principles of the mathematical description and synthesis of flexible spacecraft control are examined using an approach whereby a spacecraft is treated as a system with distributed parameters. Specific models of equations of motion and state for spacecraft are described, and methods are presented for the synthesis of optimal spacecraft control under conditions of incomplete information. Solutions to some control synthesis problems and results of numerical simulations are presented. An optimum control theory for stochastic systems with distributed parameters is presented which is based on the correlation theory of random processes. V.L.

A88-11235
MOTION PERTURBATIONS OF A DUMBBELL IN A CENTRAL NEWTONIAN FORCE FIELD [O VOZMUSHCHENNYKH DVIZHENIIAKH GANTELI V TSENTRAL'NOM N'IUTONOVSKOM POLE SIL]
A. P. BLINOV and K. DOSYBEKOV Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 25, July-Aug. 1987, p. 502-507. In Russian. refs

The steady motion of a dumbbell is examined with reference to the generation of artificial gravity on a spacecraft. During the entire motion, both heavy points of the dumbbell modeling a spacecraft remain on a radius vector directed away from the attracting center and describe concentric circles. The stability of this motion and perturbed motions are analyzed. Attention is given in particular to the librational motion of the dumbbell in the vicinity of the steady motion. B.J.

A88-11829*# General Dynamics Corp., San Diego, Calif.
CONTROL CONSIDERATIONS FOR HIGH FREQUENCY, RESONANT, POWER PROCESSING EQUIPMENT USED IN LARGE SYSTEMS
J. W. MILDICE, K. E. SCHREINER (General Dynamics Corp., Space Systems Div., San Diego, CA), and F. WOLFF (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 350-355. Previously announced in STAR as N87-23690.

Addressed is the control of resonant power processing equipment designed to be used in an integrated high frequency (20 KHz domain), utility power system for large, multi-user spacecraft and other aerospace vehicles. It describes a hardware approach, which has been the basis for parametric and physical data used to justify the selection of high frequency ac as the PMAD baseline for the space station. This paper is part of a larger effort undertaken by NASA and General Dynamics to be sure that all potential space station contractors and other aerospace power system designers understand and can comfortably use this technology, which is now widely used in the commercial sector. In this paper, we will examine control requirements, stability, and operational modes; and their hardware impacts from an integrated system point of view. The current space station PMAD system will provide the overall requirements model to develop an understanding of the performance of this type of system with regard to: (1) regulation; (2) power bus stability and voltage control; (3) source impedance; (4) transient response; (5) power factor effects; and (6) limits and overloads. Author

A88-11908#
APPLICATION OF MAGNETIC BEARINGS TO HIGH-TORQUE, SATELLITE ATTITUDE CONTROL WHEELS
JAMES DOWNER, DAVID EISENHAURE, RICHARD HOOKNEY, and BRUCE JOHNSON (SatCon Technology Corp., Cambridge, MA) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 2. New York, American Institute of Aeronautics and Astronautics, 1987, p. 829-834. refs

The use of control moment gyros as slew actuators for large spacecraft or other payloads is considered, and an alternative magnetic bearing design employing a superconducting coil is proposed. In the present bearing design, a superconducting coil is used in order to eliminate the conventional magnetic cores and permanent magnets. A baseline superconducting magnetic bearing design is presented, and substantial improvements in mass and power consumption are realized in comparison with more conventional approaches. R.R.

A88-12813* National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.
AN AMPLITUDE MODULATED LASER SYSTEM FOR DISTANCE AND DISPLACEMENT MEASUREMENT
ROBERT S. ROGOWSKI, JOSEPH S. HEYMAN (NASA, Langley Research Center, Hampton, VA), and MILFORD S. HOLBEN, JR. (PRC Kentron, Inc., Hampton, VA) IN: Laser radar technology and applications; Proceedings of the Meeting, Quebec, Canada, June 3-5, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 86-89.

A laser distance and displacement measurement system is being developed to monitor small displacements in large space structures for strain analysis and structural control. The reflected laser beam is focused on a detector and the detected signal is mixed with the reference. Small displacements are indicated by a change in modulation frequency which is adjusted to maintain quadrature between the received signal and the reference signal from the voltage-controlled oscillator in a phase-locked loop. Measurement of absolute distance is accomplished by sweeping the modulation frequency from a quadrature lock point to an adjacent lock point. Author

A88-12814* National Aeronautics and Space Administration, Lyndon B. Johnson Space Center, Houston, Tex.
LASER DOCKING SYSTEM RADAR FLIGHT EXPERIMENT
HARRY O. ERWIN (NASA, Johnson Space Center, Houston, TX) IN: Laser radar technology and applications; Proceedings of the Meeting, Quebec, Canada, June 3-5, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 105-114.

Flight experiments to verify the Laser Docking System Radar are discussed. The docking requirements are summarized, and the breadboarded hardware is described, emphasizing the two major scanning concepts being utilized: a mechanical scanning technique employing galvanometer beamsteerers and an electronic scanning technique using an image dissector. The software simulations used to apply hardware solutions to the docking requirements are briefly discussed, the tracking test bed is described, and the objectives of the flight experiment are reviewed. C.D.

A88-13572#
SIMULATION TOOLS FOR THE DEVELOPMENT OF AN AUTONOMOUS RENDEZVOUS AND DOCKING SYSTEM
A. ELFVING and W. FEHSE (ESA, Control, Robotics and RVD Div., Noordwijk, Netherlands) ESA Journal (ISSN 0379-2285), vol. 11, no. 2, 1987, p. 197-214. refs

The use of computer simulations and test beds for the ground-based development support, performance evaluation, and

verification process for the rendezvous and docking system (RVD) is examined. The role of man in the RVD operation, the features of LEO which affect the RVD system, and RVD phases and basic strategies are discussed. A model mission for the RVD system is described. Consideration is given to the objectives, design, capabilities, and applications of the RVD guidance simulation program, the docking simulation program, performance verification software, and a European operations simulator. I.F.

A88-14596#
FEEDBACK CONTROL FOR ATTITUDE CONTROL SYSTEM OF THE ELASTIC VEHICLE
XIAOYE YE and XIANGWEI HE (Beijing Information and Control Research Institute, People's Republic of China) Acta Automatica Sinica (ISSN 0254-4156), vol. 13, May 1987, p. 184-190. In Chinese, with abstract in English. refs

In this paper, the reduced-order model of attitude control systems for elastic space vehicles is discussed by virtue of the finite bandwidth property of the controller. A design method of the control system is proposed. Taking advantage of this method, all eigenmodes of the reduced-order model can be controlled and the relation between the parameters of the controller and the eigenvalues of the closed-loop system may become simple and obvious. Author

A88-14995
CONTROL OF GRIPPER POSITION OF A COMPLIANT LINK USING STRAIN GAUGE MEASUREMENTS
D. NEMIR, A. J. KOIVO, and R. L. KASHYAP (Purdue University, Lafayette, IN) IN: IEEE Conference on Decision and Control, 25th, Athens, Greece, Dec. 10-12, 1986, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 1140-1144. NSF-supported research. refs

A self-tuning type algorithm is proposed for the control of a single rotating compliant link. At each sampling time, strain measurements along the link are used to assess modal content. Knowledge of the first mode together with the hub position may be used to determine the angular position of a hub to tip projection. A self-tuning control is devised by treating this angle as belonging to an equivalent rigid link. Laboratory experiments show this control to lead to an improved performance over a control which ignores compliance. Author

A88-15280
RENDEZVOUS AND DOCKING TECHNOLOGY FOR FUTURE EUROPEAN MISSIONS
I. WIDJAJA and J. SOMMER (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 25 p. ESA-supported research.

Future European missions will require space vehicles with RVD capabilities to provide the ability of in-orbit servicing and maintenance. ESA sponsored development activities on RVD technology comprises a variety of tasks assigned to different companies and research organizations. This paper decusses one of the key elements of RVD technology, i.e., the development of a prototype on-board software for autonomous rendezvous and proximity operations. It is expected that Columbus missions will benefit from this technology program. Current MTFF (Man Tended Free Flyer) mission concepts foresee servicing at the U.S. Space Station for which adequate rendezvous and berthing capabilities are to be provided. The conceptual design of a maneuver plan in which typical flight modes of the above mentioned prototype on-board software have been implemented, will be dicussed. The verification plan involving ground simulation facilities will be addressed. Author

A88-15804#
DEVELOPMENT EXPERIENCE OF THE ATTITUDE CONTROL SYSTEM USING SINGLE-AXIS CONTROL MOMENT GYROS FOR LONG-TERM ORBITING SPACE STATIONS
V. N. BRANETS, D. M. VAINBERG, V. P. VERESHCHAGIN, N. N. DANILOV-NiTUSOV, V. P. LEGOSTAEV (AN SSSR, Soviet Interkosmos, Moscow, USSR) et al. IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 9 p.
(IAF PAPER 87-04)

Although single-axis control moment gyroscopes, or 'gyrodins', are slightly inferior to two-axis control moment gyros in mass and power characteristics, the reliability that is a consequence of their simplicity has become very attractive for long service life space station applications. Their application to attitude control systems, however, requires the solution of complex control theory problems. Attention is presently given to the geometric configuration and electromechanical implementation of a state-of-the-art space station-applicable gyrodin. O.C.

A88-15838#
SCANNING LASER RADAR SYSTEM FOR RENDEZVOUS AND DOCKING IN SPACE
HIROBUMI SAITO, ICHIRO NAKATANI, KEIKEN NINOMIYA (Tokyo, University, Japan), and AKIRA FURUYA (Mitsubishi Electric Corp., Kamakura, Japan) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 7 p. refs
(IAF PAPER 87-53)

A scanning laser radar system for rendezvous and docking in space is being developed. This laser radar system will be utilized in an autonomous satellite retrieval experiment which is planned as one of the future missions to be conducted on Japanese Space Flyer Unit (SFU) in 1990s. Rendezvous and retrieval operation will be automatically performed by on-board instruments. The laser radar system performs ranging, tracking, as well as attitude determination in short range. Author

A88-15874#
PROBLEM OF CONTROL ARISEN DURING THE IMPLEMENTATION OF SCIENTIFIC RESEARCH PROGRAM ONBOARD THE MULTIPURPOSE ORBITAL STATIONS
V. V. RIUMIN and M. IU. BELIAEV (Mission Control Center, Moscow, USSR) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 8 p. refs
(IAF PAPER 87-105)

Some control problems which directly affect the effectiveness of a scientific research mission are examined with reference to the experience derived from the operation of Salyut and Mir orbital stations. In particular, it is noted that the successful implementation of planned experiments and correct interpretation of experimental results depend to a large extent on the availability of accurate information on the actual physical environment onboard the orbital station. The importance of special mathematical models in mission planning and control is emphasized. V.L.

A88-15943#
DEVELOPMENT SCENARIO OF H-II ORBITING PLANE, HOPE
T. ITO, S. MATSUBARA, H. KATSUTA, T. AKIMOTO, and Y. TAKIZAWA (National Space Development Agency of Japan, Tokyo) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 9 p.
(IAF PAPER 87-210)

The H-II Orbiting Plane, or 'HOPE', fully reusable manned space plane is under study by NASDA as the basis of low operational cost space transportation early in the 21st century. HOPE would be intensively used in connection with manned occupation of the Japanese Experiment Module component of the International Space Station program. Attention is presently given to the performance requirements and projected system features and capabilities of the HOPE vehicle, which would be of 10-ton gross mass. An account is given of the prospective HOPE mission profile. O.C.

A88-16016#
STRUCTURAL DESIGN AND DECOUPLED CONTROL
ROBERT A. CALICO (USAF, Institute of Technology, Wright-Patterson AFB, OH) and FRANKLIN E. EASTEP (Dayton,

University, OH) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 9 p. refs
(IAF PAPER 87-318)

The decoupled control of an optimally designed space structure is considered. The optimal structure is a derivative of the CSDL I model spacecraft. In particular, the effects of structural perturbations on the optimal design are considered. The stiffness matrix for the structure is perturbed by changing the areas of its rod members. A LQR controller with modal suppression is designed for the nominal system. The controller is used on the perturbed systems and the effects on modal suppression noted. The spillover into the suppressed modes due to perturbations is also quantified in terms of the change in the row and column space of the control and observation matrices, respectively. The results obtained are compared to those obtained for the nominal CSDL I model.
Author

A88-16020#
NUMERICAL AND NUMERICAL-ANALYTICAL INTERFACES IN STRUCTURAL THERMAL-DYNAMIC INTERACTIVE PROBLEMS
CARLO ARDUINI and UGO PONZI (Roma I, Universita, Rome, Italy) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 29 p.
(IAF PAPER 87-322)

The 'extrapolation' and 'interpolation' techniques necessary to interface models of very different phenomena for a global numerical simulation of large space systems are considered. Characteristics and limitations of the extrapolation method are first reviewed with reference to thermal-conductive models, and the technique is demonstrated with an example of conductive extrapolation. The interpolation technique is then discussed with reference to dynamic models and is illustrated with the example of the interpolating of modal information from a continuous to a discrete model. R.R.

A88-16024*# Rice Univ., Houston, Tex.
OPTIMAL TRAJECTORIES FOR AEROASSISTED, NONCOPLANAR ORBITAL TRANSFER. II - LEO-TO-LEO TRANSFER
A. MIELE (Rice University, Houston, TX), K. D. MEASE (California Institute of Technology, Jet Propulsion Laboratory, Pasadena), and W. Y. LEE IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 20 p. Research supported by the Boeing Military Aircraft Co. refs
(Contract JPL-956415)
(IAF PAPER 87-328)

Both classical and minimax problems of optimal control arising in the study of noncoplanar, aeroassisted orbital transfer are considered and are illustrated with the example of LEO-to-LEO transfer. Trajectory control is achieved by modulation of the lift coefficient and the angle of bank. Problems considered include the minimization of the energy required for orbital transfer, maximization of the flight time during the atmospheric portion of the trajectory, and minimization of the peak heating rate. The near-grazing solution is found to be a good compromise between energy and heating requirements. R.R.

A88-16039#
ANGULAR MOMENTUM MANAGEMENT FOR LEO PLATFORMS
R. C. ROGERS (British Aerospace, PLC, Space and Communications Div., Stevenage, England) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 8 p.
(IAF PAPER 87-349)

The paper reviews the disturbance torques which act on an orbiting platform in Low Earth Orbit. The dependence of momentum dumping requirements on platform orientation is described and the possibility of cancellation between different disturbance torques considered. An approach to momentum dumping using magnetorquers is described, of particular relevance to a platform in an inertially fixed orientation. Author

A88-16041# Howard Univ., Washington, D. C.
THE DYNAMICS AND CONTROL OF LARGE SPACE STRUCTURES AFTER THE ONSET OF THERMAL SHOCK
PETER M. BARNUM, N. HAMSATH, and R. KRISHNA (Howard University, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 11 p. Research supported by Howard University and NASA. refs
(IAF PAPER 87-351)

This paper considers the problem of predicting the open and closed loop dynamics of large space structures after the onset of thermal shock. The thermal gradients induced in space structures due to solar radiation heating result in thermal deformations. The temperature gradient time history, the related thermal deflection response, the moments acting on a thermally deflected beam, and the control effort required for different combinations of solar incidence angles and material properties are considered in this investigation. The analysis is performed for structures which are nominally inertially stabilized as well as gravity stabilized. For the case of basic orbiting structural elements, such as a free-free plate (modeled as a beam in-plane), depending on the orientation, and required pointing accuracy, it may be necessary to redesign control algorithms previously developed for models which exclude the thermal shock effects. Author

A88-16043#
DYNAMICS AND CONTROL DURING SLEWING MANEUVERS
H. W. MAH, V. J. MODI (British Columbia, University, Vancouver, Canada), Y. MORITA, and H. YOKOTA (Tokyo, University, Japan) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 38 p.
(Contract NSERC-G-1547)
(IAF PAPER 87-353)

The librational dynamics of a flexible platform for the support of a mobile base that is connected to a series of slewing, flexible appendages is presently studied in light of a general formulation applicable to missions requiring slew maneuvers for antennas, telescopes, observational instruments, and remote manipulators. The formulation's application is illustrated by a rigid-platform satellite with slewing rigid appendage, a flexible beam-type platform with a flexible slewing arm, and a configuration representing a Space Shuttle-based flexible boom with a rigid reflector at its end. The results obtained indicate system instability under critical combinations of inertia parameters, orbit geometries, and translational and slewing-time histories. O.C.

A88-16044#
MISSION FUNCTION CONTROL APPLIED TO SLEW MANEUVER
HIRONORI FUJII and SHINTARO ISHIJIMA (Tokyo Metropolitan Institute of Technology, Japan) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 6 p. refs
(IAF PAPER 87-354)

A new control algorithm, named the mission function control, is introduced and applied to slew maneuver of a spacecraft with a flexible appendage. The control algorithm is a type of the Liapunov's method applied to a mechanical system combined with a control system and employs the concept of the generalized energy functions. The flexible appendage is modeled in terms of the partial differential equations which is believed to describe most precisely the distributed systems. Implementation of the control algorithm naturally results with physical meanings and it is shown that it is necessary to sense the shearing force and bending moment at the root of the flexible appendage. Results of numerical simulation show an excellent controlled behavior for the slew maneuver. Author

A88-16045#
THE PASSIVE ATTITUDE MOTION OF THE ORBITAL STATIONS SALYUT-6 AND SALYUT-7
V. A. SARYCHEV, V. P. LEGOSTAEV, V. V. SAZONOV, M. IU. BELIAEV, I. N. GANSVIND (AN SSSR, Sovet Interkosmos, Moscow, USSR) et al. IAF, International Astronautical Congress, 38th,

Brighton, England, Oct. 10-17, 1987. 7 p. refs
(IAF PAPER 87-355)

The paper deals with two main uncontrolled attitude motion regimes of the orbital stations Salyut-6 and Salyut-7: the single axis gravitational orientation regime and the slow rotation regime. The peculiarities of dynamics and practical applications of these regimes are given. The paper describes integral statistic methods of the determination of passive rotational motion of the stations according to the onboard attitude sensor measurements. The examples of using these methods for the solution of some scientific problems (calculations of the microacceleration at the station, the processing of star photometer indications, etc.) are given. An analysis of dynamic effects revealed through the processing of measurements made during long periods of passive spaceflight is performed. Author

A88-16049#
ACCELERATION MEASUREMENT AND MANAGEMENT ON A SPACE STATION

CHARLES A. LUNDQUIST and J. IWAN D. ALEXANDER (Alabama, University, Huntsville) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 6 p. refs
(IAF PAPER 87-364)

Ultimately, the capability is needed to actively position the line of minimum acceleration through prescribed experiment locations on a space station. For accelerations varying on time scales comparable to, or longer than, the orbital period, the acceleration depends on the rotational motion of the station, on atmospheric drag, on gravity gradient effects, and on the instrument position relative to the center of mass. For a busy station, the center of mass will not be well located unless it is determined by on-board instrumentation. For a station with geocentric radial attitude in a circular orbit, the combined acceleration due to gravity gradients and station rotation has two components: one in the radial direction and a second normal to the orbit plane. The main component of atmospheric drag has the direction of the velocity vector. Measurements by three orthogonal linear accelerometers can be used to determine the drag acceleration and two orthogonal coordinates of the center of mass. This determination requires knowledge of orbital and attitude parameters. The processed accelerometer results can serve as signals to devices that displace mass to adjust the center of mass and the minimum acceleration line to desired positions. Author

A88-16093*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AEROASSISTED-VEHICLE DESIGN STUDIES FOR A MANNED MARS MISSION

GENE P. MENEES (NASA, Ames Research Center, Moffett Field, CA) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 14 p. refs
(IAF PAPER 87-433)

An aerobrake design accounting for all of the important flow phenomenology which are characteristic of aerobraking vehicles is proposed as the mission baseline. Flight regimes and aerothermal environments for both Mars and earth entry are calculated using advanced methods to account for real-gas, thermochemical, relaxation effects. The results are correlated with thermal-protection and structural requirements and mission performance capability. The importance of nonequilibrium radiative heating for earth aerocapture is demonstrated. It is suggested that two aerobrakes of different sizes will produce optimal performance for the three phases of the mission (i.e., one aerobrake for Mars aerocapture and descent of the surface lander and another for earth return). Author

A88-16276
AUTOMATIC CONTROL IN SPACE 1985

J. P. CHRETIEN, ED. (Toulouse, Centre d'Etudes et de Recherches, France) Oxford and New York, Pergamon Press, 1986, 323 p. For individual items see A88-16277 to A88-16313.

The present conference on automatic control of space systems discusses topics in the fields of GEO satellite operations, highly instrumented scientific satellites, LEO satellite operations, flexible spacecraft systems, orbit and trajectory control, spacecraft component technology, and the control of platforms and manipulators. Attention is given to such specific issues as Italsat's antenna fine pointing system, solar sailing attitude control for a large GEO satellite, the Galileo attitude and articulation control system, and the attitude control system of a polar-orbiting meteorological satellite. Also discussed are the control of tethered satellite systems, autonomous satellite navigation using opticoinertial instruments, and the Hubble Space Telescope Rate Gyro assembly. O.C.

A88-16280
SOLAR SAILING ATTITUDE CONTROL OF LARGE GEOSTATIONARY SATELLITE

J. LIEVRE (Matra, S.A., Velizy-Villacoublay, France) IN: Automatic control in space 1985. Oxford and New York, Pergamon Press, 1986, p. 29-32.

Solar pressure effects on GEO satellites can be harnessed by means of solar sails to furnish attitude control. In the case of the OTS2 satellite, two fixed solar sails are mounted on the solar arrays in order to improve control efficiency; disturbance-related torques are estimated by the ground station, and compensated for by solar array pointing angle, while control torques are achieved by low depointing of the solar arrays to angles that are computed onboard. The total required depointing of the solar arrays limits their efficiency loss to 1 percent. O.C.

A88-16281
EVALUATION OF CONTROL CONCEPTS FOR A LARGE GEOSTATIONARY DATA RELAY SATELLITE

M. CALDICHOURY (Matra, S.A., Velizy-Villacoublay, France) IN: Automatic control in space 1985. Oxford and New York, Pergamon Press, 1986, p. 33-42. refs

This paper presents some results obtained during the investigation of attitude and antenna pointing control systems for a large geostationary Data Relay Satellite; due to high requirements in terms of pointing accuracy and admissible defocusing, the problem of interaction between the spacecraft structure and control has a considerable significance. The modelization of flexible substructures and liquid sloshing, and the derivation of linear and nonlinear models are described. A comparative study of several control concepts, with or without active control of flexible modes, is presented here for both normal and station-keeping modes. Simulation results and performance evaluations of selected control systems are shown. The study synthesis leads to point out some recommendations for further studies. Author

A88-16296
APPLICATION OF ADAPTIVE OBSERVERS TO THE CONTROL OF FLEXIBLE SPACECRAFT

S. V. SALEHI (British Aerospace, PLC, Space and Communications Div., Bristol, England) IN: Automatic control in space 1985. Oxford and New York, Pergamon Press, 1986, p. 167-174. refs
(Contract ESA-5665/83)

A difficulty in the control of large flexible structures arises from model uncertainty of a deterministic nature. The modern state-space theory of quadratic regulators yields a robust feedback design, that is one that is relatively insensitive to uncertainty. However, the state estimator (i.e., asymptotic observer) limits the overall robustness of the controller. State estimation may be enhanced by using Kreisselmeier's (1982) continuous-time adaptive observer, modified to adapt on a small number of physically meaningful parameters. The above techniques are applied to the stationkeeping-mode attitude control of a possible growth version of Olympus having much larger solar arrays. No special test signal is used to force the convergence of the parameter identification loop. The controllers are evaluated in the presence of noise, thruster nonlinearity and unmodeled dynamics. The use of the adaptive observer is found to enhance the robustness of the controller, while maintaining the pointing within specification. The method shows promise for more general flexible space structures. Author

A88-16311
CONTROL TECHNIQUES FOR RENDEZ-VOUS AND DOCKING
B. CLAUDINON (Matra, S.A., Velizy-Villacoublay, France), PH. MARCHAL (CNES, Toulouse, France), and W. FEHSE (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IN: Automatic control in space 1985. Oxford and New York, Pergamon Press, 1986, p. 287-294. refs

An evaluation is made of novel control system alternatives for the on-board estimation of the homing, approach, and docking phases of spacecraft. The algorithms discussed represent control theory applications involving state observers and state controllers. The number of mission phases and reference frames that have to be considered makes on-board algorithm implementation extremely complex. The performance levels achievable are illustrated with simulations; a low-impact docking concept is envisioned on the basis of the present techniques for future in-orbit operations. O.C.

A88-16312
CONTROL OF IN-ORBIT SPACE MANIPULATION
J. L. LACOMBE and TH. BLAIS (Matra, S.A., Velizy-Villacoublay, France) IN: Automatic control in space 1985. Oxford and New York, Pergamon Press, 1986, p. 295-302.

An account is given of the primary applications of robotics, telemanipulation, and servicing technologies, in the context of special space constraints and critical manipulator control problems. Attention is given to such aspects of control as electrical system architecture, proprioceptive and exteroceptive sensors, and man-machine task sharing. The progress made to date with terrestrial manipulator control systems is evaluated. The focus of these technology development efforts is the emerging set of robotics systems requirements associated with ESA's Hermes reusable manned orbiter. O.C.

A88-16976
GUIDANCE AND CONTROL 1987; PROCEEDINGS OF THE ANNUAL ROCKY MOUNTAIN GUIDANCE AND CONTROL CONFERENCE, KEYSTONE, CO, JAN. 31-FEB. 4, 1987
ROBERT D. CULP, ED. (Colorado, University, Boulder) and TERRY J. KELLY, ED. (Ball Corp., Ball Aerospace Systems Div., Boulder, CO) Conference sponsored by AAS. San Diego, CA, Univelt, Inc., 1987, 638 p. For individual items see A88-16977 to A88-17000, A88-17002 to A88-17008.

The conference presents papers on innovative approaches to guidance, navigation, and control; guidance and control storyboard displays; test versus simulation in development of guidance and control systems; remote operations through robotics; and recent experiences. Particular attention is given to fault protection design for unmanned interplanetary spacecraft, linear quadratic stationkeeping on travelling ellipses, a heirarchic control architecture for intelligent structures, gyro technology, and the development and testing of a breadboard model star sensor for application in spacecraft systems. Other topics include directed energy weapons tracking and pointing space experiments, dynamics and control of a planar manipulator with elastic links, in-flight experiences with the attitude control system of the IRAS, and GPS reaction wheel system anomaly. K.K.

A88-16998
STABILITY ANALYSIS FOR ALTERNATIVE FORCE CONTROL SCHEMES AS APPLIED TO REMOTE SPACE TELEOPERATION
JIM D. CHAPEL and DALE A. LAWRENCE (Martin Marietta Corp., Denver, CO) IN: Guidance and control 1987; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Jan. 31-Feb. 4, 1987. San Diego, CA, Univelt, Inc., 1987, p. 399-415. refs
(AAS PAPER 87-043)

In an attempt to understand the observed behavior of force feedback teleoperation in tasks involving environmental interaction, consideration is given to a dynamic model of the system along a single Cartesian degree of freedom. A comparison made between the stability properties of this model and a full 6-DOF hardware implementation, using a software hand controller emulation, reveals the fidelity of this model along a single degree of freedom. It is found that an impedance control structure can provide substantial performance advantages especially when significant communication delays are present. K.K.

A88-21647* Rockwell International Corp., Downey, Calif.
AN ORBITING CONTROL STATION FOR FREE-FLYING TELEOPERATORS - PRELIMINARY DESIGN METHODOLOGY
M. M. CLARKE, E. Y. MOK, W. B. ROSENFIELD (Rockwell International Corp., Space Station Systems Div., Downey, CA), and A. QUINN (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 155-160. refs

This paper summarizes work being done to develop the preliminary design of a control station for the free-flying teleoperator/telerobot ROBIN. The four-step development process involves telerobot capability definition, mission analysis, requirements generation, and design solution. The ROBIN servomanipulator requirements are listed, and a telerobotic control station requirement tree is shown. C.D.

A88-21657
VIDEO-BASED SATELLITE ATTITUDE DETERMINATION
ROBERT L. RUSSELL and ANDREW J. D'ARCY (RCA Advanced Technology Laboratories, Moorestown, NJ) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 231-235.

In this paper, an approach to solving the attitude determination problem for satellites is presented. The technique uses standard CCD video and requires the identification of the camera plane coordinates of at least three known points on the object. To facilitate detection of these points, illuminated retroreflectors are mounted in a known configuration on the satellite's surface. A CCD camera equipped with a computer-controlled focus, iris, and zoom is used to detect the reflector locations. Image processing is used to distinguish the reflectors from the background. Once the reflector image is found, the reflector centroid can be determined. These centroids, together with knowledge of the original location of the reflectors on the satellite, are used to compute the attitude. C.D.

A88-22501#
FEEDBACK CONTROL DESIGN FOR SMOOTH, NEAR MINIMUM TIME ROTATIONAL MANEUVERS OF FLEXIBLE SPACECRAFT
S. R. VADALI (Texas A & M University, College Station) and R. M. BYERS AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. Research supported by Martin Marietta Corp. refs
(Contract F49620-86-K-00014)
(AIAA PAPER 88-0671)

The single axis slewing of a flexible spacecraft using bounded torque in near minimum time with simultaneous suppression of vibration of elastic modes is considered. The Hyperbolic Tangent (tanh) function is used as a smooth approximation of the discontinuous sign function in the rigid body 'bang-bang' control. Variable structure control concepts are used to identify the necessary characteristics of the control switching line. Simulations of the rest-to-rest and tracking maneuvers indicate that the elastic energy can be reduced by several orders of magnitude with only a modest increase in the maneuver time. Author

A88-22502#
SPACE STATION ATTITUDE CONTROL MOMENTUM REQUIREMENTS
BRENT P. ROBERTSON and MICHAEL L. HECK (Analytical Mechanics Associates, Inc., Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 15 p. refs
(AIAA PAPER 88-0672)

The relationship between attitude and angular momentum

control requirements is derived for a fixed-attitude, earth-orbiting spacecraft with large area articulating appendages. Environmental effects such as gravity gradient, solar radiation pressure, and aerodynamic forces arising from a dynamic, rotating atmosphere are examined. It is shown that, in general, each environmental effect contributes to both cyclic and secular momentum requirements both within and perpendicular to the orbit plane. The gyroscopic contribution to the angular momentum control requirements resulting from the rotating, earth-oriented spacecraft is also discussed. Special conditions are described whereby one or more components of the angular momentum can be made to vanish, or become purely cyclic. Computer generated plots for a candidate Space Station configuration are presented to supplement the analytically derived results. Author

A88-22504#
A RELATIVELY GENERAL FORMULATION FOR STUDYING DYNAMICS OF THE SPACE STATION BASED MRMS WITH APPLICATIONS
H. W. MAH, V. J. MODI (British Columbia, University, Vancouver, Canada), and Y. MORITA (Tokyo, University, Japan) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p.
(AIAA PAPER 88-0674)

The paper presents a relatively general formulation for studying librational dynamics of a flexible platform supporting a mobile base connected to a series of slewing, flexible appendages. It is applicable to missions requiring slew maneuvers of antennas, telescopes, scientific instruments, and in particular, the U.S. proposed Space Station's Mobile Remote Manipulator System (MRMS). The formulation is applied to the SCOLE configuration representing the Space Shuttle based flexible beam supporting a rigid reflector at its end. The analysis provides a useful insight into interactions between inertia parameters, orbit geometry, translational and slewing time histories, flexibility and initial conditions. Results suggest that under critical combinations of the parameters the system may become unstable. Author

A88-22505*# Howard Univ., Washington, D. C.
MINIMUM TIME ATTITUDE SLEWING MANEUVERS OF A RIGID SPACECRAFT
FEIYUE LI and PETER M. BAINUM (Howard University, Washington, DC) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(Contract NSG-1414)
(AIAA PAPER 88-0675)

The minimum time attitude slewing motion of a rigid spacecraft with its controls provided by torques and forces, which have their upper and lower limits prescribed, is considered. The two-point boundary-value problem is derived by applying the Pontriagin's Maximum Principle to the system and solved by using a quasi-linearization algorithm. The nominal solutions to the problem as well as the starting values of the total slewing time and the unknown initial costates for this algorithm are generated by using Euler's eigenaxis rotation theorem. It is pointed out that one of the four initial costates associated with the quaternions can be arbitrarily selected without affecting the optimal controls and, thus, simplifying the computation. The minimum slewing time is determined by shortening the total slewing time until at least one of the controls becomes a bang-bang type. Several numerical tests for the rigidized SCOLE model are presented to show the applications of the methods. Author

A88-22507*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TECHNIQUES FOR ASSESSMENT OF FLEXIBLE SPACE STRUCTURE CONTROL PERFORMANCE
LAWRENCE F. ROWELL (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 17 p. refs
(AIAA PAPER 88-0677)

Several multivariable concepts are presently applied to both the open-loop and closed-loop analysis of a wrap-rib antenna space structure. After evaluating the alternative placements of sensors and actuators by means of controllability, observability, and transmission-zero concepts, the linear quadratic gaussian/loop transfer recovery method is used to synthesize a control law for suppression of the transient vibrations that are typically encountered during maneuvers. The integration of these techniques and associated computer programs into a larger spacecraft design system is also discussed. O.C.

A88-22609#
DYNAMICS OF EARTH-ORBITING FLEXIBLE SATELLITES WITH MULTIBODY COMPONENTS
L. VU-QUOC and J. C. SIMO (Stanford University, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, Nov.-Dec. 1987, p. 549-558. refs
(Contract AF-AFOSR-83-0361)

A novel approach to the dynamics of satellites with flexible multibody components is proposed. The property of invariance under superposed rigid-body motions of geometrically-exact structural theories is employed to refer the dynamics of motion directly to the inertial frame. To avoid numerical ill conditioning, the dynamics of the far field and the near field are treated separtely by introducing a rotationally-fixed floating frame, which is a parallel translate of the inertial frame. Constraint conditions to determine the orientation of floating frames proposed in the past are thus entirely bypassed. The proposed formulation can accommodate an unrestricted class of maneuvers under the action of follower forces and gravitational force, and is particularly suited for the dynamics of flexible multibody systems undergoing a broad range of deformations. Author

A88-22932* Virginia Polytechnic Inst. and State Univ., Blacksburg.
MANEUVERING AND VIBRATION CONTROL OF FLEXIBLE SPACECRAFT
L. MEIROVITCH (Virginia Polytechnic Institute and State University, Blacksburg) and R. D. QUINN (Case Western Reserve University, Cleveland, OH) Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 35, July-Sept. 1987, p. 301-328. refs
(Contract NAG1-225)

This paper is concerned with the problem of slewing a large structure in space and suppressing any vibration at the same time. The structure is assumed to undergo large rigid-body motions and small elastic deformations. A perturbation method permits a maneuver strategy independent of the vibration control. Optimal control and pole placement techniques, formulated to include first-order actuator dynamics, are used to suppress the vibration during maneuver. The theory is illustrated by simultaneous maneuvering and vibration control of the Spacecraft Control Laboratory Experiment (SCOLE) model in a space environment. Author

A88-22933* Nevada Univ., Las Vegas.
ATTITUDE CONTROL OF A THREE ROTOR GYROSTAT IN THE PRESENCE OF UNCERTAINTY
SAHJENDRA N. SINGH (Nevada, University, Las Vegas) Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 35, July-Sept. 1987, p. 329-345. refs
(Contract NAS1-17919)

A nonlinear control law for large angle rotational maneuvers of spacecraft using reaction wheels in the presence of uncertainty is presented. The derivation of this suboptimal control law does not require any information on the values of the system parameters and the disturbance torques acting on the spacecraft. The controller includes a dynamic system in the feedback path. The control law is a nonlinear function of the attitude error, the rate of the attitude error and the compensator state. Simulation results are presented to show that large angle rotational maneuvers can be performed in spite of the uncertainty in the system. Author

A88-23982#
DECENTRALIZED/HIERARCHICAL CONTROL FOR LARGE FLEXIBLE SPACECRAFT

K. JANSCHEK and M. SURAUER (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) IFAC, World Congress, 10th, Munich, Federal Republic of Germany, July 26-31, 1987, Paper. 9 p. refs
(MBB-UR-967-87)

A MIMO design procedure for flexible spacecraft and equipment modeling based on a well-known sequential design approach is described which permits the user to deal with robust stabilization of flexible structural modes, complex equipment dynamics, time delay due to measurement/control algorithm processing, hybrid continuous/discrete time control loops, and nonlinearities. The boundary conditions that must be observed for the selection of an appropriate control concept and the general tasks for the different control loops are summarized. Some typical sample results are given for a communication satellite configuration. C.D.

A88-24281* Nevada Univ., Las Vegas.
FLEXIBLE SPACECRAFT MANEUVER - INVERSE ATTITUDE CONTROL AND MODAL STABILIZATION
SAHJENDRA N. SINGH (Nevada, University, Las Vegas) Acta Astronautica (ISSN 0094°5765), vol. 17, Jan. 1988, p. 1-9. NASA-supported research. refs

A control law is presented for three-axis rotational maneuvers of a spacecraft (orbiter)-beam-tip body (antenna or a reflector) configuration based on nonlinear inversion and modal velocity feedback. Using invertibility and functional reproducibility results, a decoupling attitude control law is presented such that, in the closed-loop system, the attitude angles of the spacecraft are independently controlled using the control moments acting on the space vehicle. This controller asymptotically decouples the flexible dynamics from the rigid one and also allows the decomposition of the elastic dynamics into two subsystems representing the transverse deflections of the beam in two orthogonal planes. These low-order subsystems are used for derivation of a modal velocity feedback stabilizer using the force and moment actuators at the end body. Simulation results are presented to show that, in the closed-loop system, attitude control and elastic mode stabilization are accomplished in spite of the parameter uncertainty and disturbance torque input in the system. Author

A88-24506#
ROOT LOCUS METHOD FOR ACTIVE CONTROL OF FLEXIBLE SYSTEMS
NORIHIRO GOTO (Kyushu University, Fukuoka, Japan) and SHINJI HOKAMOTO Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 30, Nov. 1987, p. 150-161. refs

Precise attitude and shape control of flexible spacecraft requires active control of flexural vibrations. This work is concerned with the root locus method applied to active vibration control systems for a certain class of flexible bodies. A general characteristic equation is first derived for a feedback system to control flexural vibrations with arbitrary numbers of sensors and actuators. Then it is shown for the first time that the characteristic equation in a determinantal form may be reduced to a mathematically tractable form. It is also shown that under the condition of colocation of sensors and actuators the characteristic equation takes a form by which the significance of the condition can be readily appreciated. Finally the paper presents a numerical study to illustrate a practical procedure of applying the root locus method to flexural vibration control systems. Author

A88-25797
OPTIMIZATION OF ACTIVELY CONTROLLED STRUCTURES USING GOAL PROGRAMMING TECHNIQUES
S. S. RAO (Purdue University, West Lafayette, IN), V. B. VENKAYYA, and N. S. KHOT (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 26, Jan. 1988, p. 183-197. USAF-sponsored research. refs

The problem of design of actively controlled structures subject to restrictions on the damping parameters of the closed-loop system is formulated and solved as a multiobjective optimization problem. The purpose of control is to effectively suppress structural vibrations due to initial excitation. The cross-sectional areas of the members are treated as design variables. The structural weight and the controlled system energy are considered as objective functions for minimization. The goal programming approach is used for the solution of the multiobjective optimization problems. The procedure is illustrated through numerical simulations using two-bar and twelve-bar truss structures. Author

A88-25854
PROPOSAL OF ADAPTIVELY CONTROLLED TRANSMITTING ARRAY FOR MICROWAVE POWER TRANSMISSION IN SPACE
K. KOMOYAMA and I. YOKOSHIMA (Ministry of International Trade and Industry, Electrotechnical Laboratory, Tsukuba, Japan) Electronics Letters (ISSN 0013-5194), vol. 24, Jan. 21, 1988, p. 87-89. refs

An adaptively controlled transmitting antenna array system is proposed for use in microwave energy transmission between spacecraft. Monitoring detectors are used for feedback control of both main beam and sidelobe. Computer simulation shows the possibility of accurate control for the main beam and a sidelobe. Author

A88-26356#
AN EXPERIMENTAL STUDY ON FLEXIBLE SPACECRAFT THREE-AXIS ATTITUDE CONTROL
TAKASHI KIDA, ISAO YAMAGUCHI, OSAMU OKAMOTO, YOSHIAKI OHKAMI, SHINICHIRO ICHIKAWA et al. Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 35, no. 407, 1987, p. 569-576. In Japanese, with abstract in English. refs

This paper studies three-axis attitude-control problems of a class of flexible spacecraft having elastic appendages. A linear quadratic regulator (LQR) associated with a state estimator is designed to control its attitude and the appendage vibration, simultaneously. In order to evaluate and demonstrate the controller performance, ground-based control experiments are conducted, using an ETS-VI laboratory model supported on a single-axis air table. The evaluation is made concered mainly with (1) LQR realization by using a thruster and a reaction wheel, and (2) stability robustness against the truncated vibration modes of flexible appendages. Author

A88-27301
1987 AMERICAN CONTROL CONFERENCE, 6TH, MINNEAPOLIS, MN, JUNE 10-12, 1987, PROCEEDINGS. VOLUMES 1, 2, & 3
Conference sponsored by the American Automatic Control Council. New York, Institute of Electrical and Electronics Engineers, 1987, p. Vol. 1, 816 p.; vol. 2, 758 p.; vol. 3, 701 p. For individual items see A88-27302 to A88-27425.

Papers are presented on stochastic control, robotics, variable structure control, adaptive control, nonlinear process control, aerospace applications, estimation, and robust control via Lyapunov methods. Also considered are knowledge-based systems for control design, multitarget control of uncertain systems, multitarget tracking and sensor fusion, simulation in guidance and control systems, and computer science applications to control. Other topics include the decentralized control of large space structures, the modeling and control of solar energy processes, industrial applications of self-tuning and predictive control, and identification. Papers are also presented on state-space self-tuning control, synthesis techniques, the modeling of flexible structures, light-of-sight stabilization/tracking systems, order reduction, intelligent control systems, and energy systems analysis and control. R.R.

A88-27358
STRUCTURAL DECOMPOSITION APPROACH TO DESIGN OF ROBUST DECENTRALIZED CONTROLLERS FOR LARGE SCALE SYSTEMS
J. V. MEDANIC, H. S. THARP, and W. R. PERKINS (Illinois, University, Urbana) IN: 1987 American Control Conference, 6th,

Minneapolis, MN, June 10-12, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1987, p. 976-981. refs

This paper describes an integrated methodology for determining a decentralized control structure for LSS with corresponding low-order controllers. Structural decomposition is based on the use of the Generalized Hessenberg Representation (GHR). Controller design is accomplished by utilizing frequency weighting in the performance criterion, together with projective controls. The methodology is illustrated by a case study of a 40th-order space structure model. Author

A88-27364* Nevada Univ., Las Vegas.
THREE AXIS ROTATIONAL MANEUVER AND VIBRATION STABILIZATION OF ELASTIC SPACECRAFT
SAHJENDRA N. SINGH (Nevada, University, Las Vegas) IN: 1987 American Control Conference, 6th, Minneapolis, MN, June 10-12, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1987, p. 1106-1111. NASA-supported research. refs

A control law for three-axis rotational maneuvers of a spacecraft beam-tip body configuration based on non-linear inversion and modal velocity feedback is presented. A decoupling attitude control law is presented such that in the closed-loop system the attitude angles of the spacecraft are independently controlled, using the control moments acting on the space vehicle. This controller asymptotically decouples the flexible dynamics from the rigid one and also allows the decomposition of the elastic dynamics into two subsystems representing the transverse deflections of the beam in two orthogonal planes. These low-order subsystems are used for the derivation of a modal velocity feedback stabilizer using the force and moment actuators at the end body. Simulation results are presented to show the capability of the controller. Author

A88-27367* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DESIGN OF ROBUST LINE-OF-SIGHT POINTING CONTROL SYSTEM FOR THE SCOLE CONFIGURATION
S. M. JOSHI and E. S. ARMSTRONG (NASA, Langley Research Center, Hampton, VA) IN: 1987 American Control Conference, 6th, Minneapolis, MN, June 10-12, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1987, p. 1125-1127. refs

Robust compensator design for attitude control of the Spacecraft Control Laboratory Experiment (SCOLE) configuration is considered. A loop-shaping procedure similar to that used in the LQG/LTR method is used to iteratively design the compensator. A satisfactory compensator is obtained by including the rigid modes and three elastic modes in the design model. C.D.

A88-27397
SENSOR AND ACTUATOR SELECTION FOR OPTIMAL CLOSED-LOOP PERFORMANCE IN THE PRESENCE OF CORRELATED NOISE
G. A. NORRIS and R. E. SKELTON (Purdue University, West Lafayette, IN) IN: 1987 American Control Conference, 6th, Minneapolis, MN, June 10-12, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1987, p. 1337-1341. refs

A method is presented for the selection of sensors and actuators whose outputs may contain correlated noise. A generalization of the earlier results of Closed-Loop Input/Output Cost Analysis (CIOCA) is provided which utilizes decompositions of the closed-loop quadratic cost function into contributions from each stochastic noise input and each weighted output. It is shown that under certain circumstances the elimination of a correlated noise input may degrade performance. Application to a flexible space structure demonstrates the generalized method for sensor and actuator selection. Author

A88-27402
(M,N)-APPROXIMATION - A SYSTEM SIMPLIFICATION METHOD
A. YOUSUFF (Drexel University, Philadelphia, PA), T. E. MCQUADE, and S. S. BANDA (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: 1987 American Control Conference, 6th, Minneapolis, MN, June 10-12, 1987, Proceedings. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1987, p. 1534-1536. refs
(Contract F49620-85-C-0013)

The need for approximation of model systems has increased since the realization of large space structures and high-speed and supermaneuverable aircraft that undergo rapid dynamic changes. This paper presents a method for simplifying systems made up of N interconnected subsystems by approximating only M of the N subsystems. Each of the M subsystems is reduced while all interactions are active, and the identities of all subsystems in the overall approximation are preserved. A new version of balanced controllers is shown to be generated by this method. A numerical example is included which compares the new method with other balancing methods, and the results are shown to favor the new method. C.D.

A88-27404* Texas Univ., Arlington.
LYAPUNOV FUNCTION GRADIENT GENERATED ROBUST CONTROL IN THE ABSENCE OF THE NOMINAL STABILIZING CONTROL
C. C. BLACKWELL (Texas, University, Arlington) IN: 1987 American Control Conference, 6th, Minneapolis, MN, June 10-12, 1987, Proceedings. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1987, p. 1595-1600. refs
(Contract JPL-957451)

A relevant facet of the application of Lyapunov gradient-generated robust control to unstable linear autonomous plants is explored. It is demonstrated that if the plant, the output, and the nominal stabilizing control satisfy certain conditions, then the robust component alone stabilizes the nominal plant. An example characterized by two zero eigenvalues and two negative real value poles is presented. These results assure that the robust component will fulfill the role of nominal stabilization successfully so long as the possible magnitude of the robust component can overcome the contribution of the instability to positiveness of the Lyapunov rate. C.D.

A88-27768
IDENTIFICATION AND CONTROL OF FLEXIBLE STRUCTURES [IDENTIFICATION ET COMMANDE DES STRUCTURES FLEXIBLES]
J. P. CHRETIEN, G. HARDIER, and J. L. PAC (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) IN: Automatic systems in aeronautics; National Colloquium, Paris, France, Mar. 17-19, 1986, Proceedings. Toulouse, Cepadues-Editions, 1986, p. 455-493. In French. refs

Techniques for the active control of flexible structures and for modeling their behavior in the frequency and time domains are reviewed. The advantages of the frequency-domain approach are pointed out, and it is shown how processing of input signals and noise in the time-domain can lead to an equivalent collection of data in the frequency domain. The method is applied to the problem of the computer-aided analysis of transport aircraft flutter. The model is minimized to permit the obtaining of control laws. Canonical models are developed to solve the control problem. It is pointed out that the critical parameter of absolute damping is manifested at the level of the reduction of dimensionality, at the level of control filtering, and at the level of positive control. R.R.

A88-27779#
DESIGN AND VERIFICATION OF THE FLECS TEST STRUCTURE
E. NELLESSEN ESA Journal (ISSN 0379-2285), vol. 11, no. 3, 1987, p. 317-341. refs

This paper reports the development and dynamic identification of the FLECS test structure, designed to represent a typical modular

spacecraft in terms of mass properties and dynamic characteristics. FLECS is intended as a multipurpose test item when a structure with spacecraft properties is required, in particular for the validation of dynamic identification methods applied in a spacecraft-verification process. The generation of a finite-element model, a modal-survey test and the correlation of the analytical modal data with modal-survey test results are reported. Finally, an updating procedure for modular structures is presented. The method was tested using FLECS correlation data. Author

A88-28043*# California Univ., Los Angeles.
CONTROL-AUGMENTED STRUCTURAL SYNTHESIS
R. V. LUST and L. A. SCHMIT (California, University, Los Angeles) AIAA Journal (ISSN 0001-1452), vol. 26, Jan. 1988, p. 86-95. refs
(Contract NSG-1490)
(AIAA PAPER 86-1014)

A control-augmented structural synthesis methodology is presented in which the structural member sizes and active control system feedback gains are treated simultaneously as independent design variables. Multiple static and harmonic dynamic loading conditions are considered. Constraints are imposed on static displacements, natural frequencies, and the magnitudes of the steady-state dynamic displacements and actuator forces to ensure acceptable system behavior. Side constraints imposed on the design variables protect against the generation of unrealizable designs. Example problems are presented that demonstrate the method and underscore the importance of integrating the structural and active control system design process. Author

A88-28253#
MOMENTUM MANAGEMENT AND ATTITUDE CONTROL DESIGN FOR A SPACE STATION
HENRY H. WOO, HENLEY D. MORGAN, and ERIC T. FALANGAS (Rockwell International Corp., Downey, CA) (Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986, Technical Papers, p. 277-286) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, Jan.-Feb. 1988, p. 19-25. Research supported by Rockwell International Corp. Previously cited in issue 23, p. 3426, Accession no. A86-47430 refs

A88-31393*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
SPILLOVER STABILIZATION OF LARGE SPACE STRUCTURES
EVA A. CZAJKOWSKI, RAPHAEL T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg), and ANDRE PREUMONT (Bruxelles, Universite Libre, Brussels, Belgium) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 131-143. refs
(Contract NAG1-603)
(AIAA PAPER 88-2484)

Active control of large flexible space structures is typically implemented to control only a few known elastic modes. This paper considers the stabilization of the neglected dynamics of the higher modes of vibration. An attempt is made to design modal controllers with improved spillover stability properties. Two formulations for designing the observer to improve spillover stability with minimum performance loss are proposed. One optimizes the noise statistics used in the design of the Kalman-Bucy Filter (KBF), while the other directly optimizes the the gain matrix of the KBF. C.D.

A88-31394*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DYNAMICS AND CONTROL CHARACTERISTICS OF A REFERENCE SPACE STATION CONFIGURATION
THOMAS R. SUTTER, PAUL A. COOPER, and JOHN W. YOUNG (NASA, Langley Research Center, Hampton, VA) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 144-154.
(AIAA PAPER 88-2485)

This paper describes the structural dynamic characteristics of a NASA reference space station configuration as defined in the November 1987 Space Station Program - Systems Engineering and Integration Engineering Data Book. The modes and frequencies of the station below 2.0 Hz were obtained and selected results along with rigid body properties are presented. A three-axis attitude control system using control moment gyros responding to attitude and attitude rate signals is used to regulate the orientation of the station. The stability of the control system with non-collocated sensors is investigated for both compensated and uncompensated control signals. Results from a closed-loop simulation of a commanded attitude change about three axes, and from a closed-loop simulation of the response of the station to an externally applied unit force impulse at the docking port are presented. These simulation results are used to evaluate the possible degree of control/structures interaction which could occur during normal operation of the station. Author

A88-31399*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ORBIT LIFETIME CHARACTERISTICS FOR SPACE STATION
L. DERYDER (NASA, Langley Research Center, Hampton, VA), G. M. KELLY, and M. HECK (Analytical Mechanics Associates, Inc., Hampton, VA) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 187-195. refs
(AIAA PAPER 88-2490)

The factors that influence the orbital lifetime characteristics of the NASA Space Station are discussed. These include altitude, attitude, launch date, ballistic coefficient, and the presence of large articulating solar arrays. Examples from previous program systems studies are presented that illustrate how each factor affects Station orbit lifetime. The effect of atmospheric density models on orbit lifetime predictions is addressed along with the uncertainty of these predictions using current trajectory analyses of the Long Duration Exposure Facility spacecraft. Finally, nominal reboost altitude profiles and fuel requirement considerations are presented for implementing a reboost strategy based on planned Shuttle Orbiter rendezvous strategy and contingency considerations. C.D.

A88-31564*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
DYNAMICS AND CONTROL OF A PLANAR TRUSS ACTUATOR
V. D. LOVEJOY, H. H. ROBERTSHAW (Virginia Polytechnic Institute and State University, Blacksburg), W. N. PATTEN (Iowa, University, Iowa City), and G. C. HORNER (NASA, Langley Research Center, Hampton, VA) IN: Vibration control and active vibration suppression; Proceedings of the Eleventh Biennial Conference on Mechanical Vibration and Noise, Boston, MA, Sept. 27-30, 1987. New York, American Society of Mechanical Engineers, 1987, p. 47-55. refs
(Contract NAG1-570)

The concept of using an active truss actuator to control the vibration of a flexible (space) structure has been investigated. The actuator with a generic beam continuum cantilevered from it has been modeled using energy methods. A time-invariant optimal state feedback scheme was utilized for the control method. A digital simulation of the system dynamic response demonstrated the good vibration control possibilities for the (planar) truss actuator on a large flexible space structure. Author

A88-31565*# Texas A&M Univ., College Station.
ACTIVE VIBRATION CONTROL IN MICROGRAVITY ENVIRONMENT
C. H. GERHOLD (Texas A & M University, College Station) and R. ROCHA (NASA, Johnson Space Center, Houston, TX) IN: Vibration control and active vibration suppression; Proceedings of

the Eleventh Biennial Conference on Mechanical Vibration and Noise, Boston, MA, Sept. 27-30, 1987. New York, American Society of Mechanical Engineers, 1987, p. 57-63. refs

An active control process to reduce vibration transmitted from the Space Station structure to the vibration sensitive payload is evaluated. A low-friction air-bearing table is used to approximate zero gravity in the horizontal plane. An analog control system is described which activates calibrated air jets when displacement of the test mass is sensed. The air jet control system is found to introduce an effective damping factor in controlling the oscillatory response. The air-jet control system is designed such that the thrust force produces less than 10 to the -5th g acceleration of the payload. An analytical model has verified the amount of damping in addition to flow parameters such as the pressure drop across the valve and the air flow rate. R.R.

A88-31574#
DESIGN AND ANALYSIS OF PASSIVELY DAMPED LARGE SPACE STRUCTURES
D. R. MORGENTHALER (Martin Marietta Corp., Denver, CO) IN: The role of damping in vibration and noise control; Proceedings of the Eleventh Biennial Conference on Mechanical Vibration and Noise, Boston, MA, Sept. 27-30, 1987. New York, American Society of Mechanical Engineers, 1987, p. 1-8.

The design of passive damping into large space structures has gained increasing interest in the past several years due to the advantages inherent in a passive control design. These advantages include strict stability, high reliability, relatively low cost, and little or no power requirements. This paper includes examples of large space structures which will benefit from passive damping treatments, the design goals characteristic of these structures, and outlines a basic design approach to achieve the desired damping levels in actual hardware. The paper also shows the application of the design method to structures which have been fabricated and dynamically tested for damping performance under the Passive and Active Control of Space Structures program. Author

A88-31596#
INVESTIGATION OF DAMPING FROM NONLINEAR SLEEVE JOINTS OF LARGE SPACE STRUCTURES
A. A. FERRI (Georgia Institute of Technology, Atlanta) IN: The role of damping in vibration and noise control; Proceedings of the Eleventh Biennial Conference on Mechanical Vibration and Noise, Boston, MA, Sept. 27-30, 1987. New York, American Society of Mechanical Engineers, 1987, p. 187-195. Research supported by Honeywell, Inc. refs

A nonlinear sleeve joint model which accounts for the presence of clearances, impact damping and dry (Coulombic) friction is developed. By studying the free and forced response of this model, it is seen that the overall damping appears to be predominantly viscouslike in nature. This is found to be true even for the cases studied where dry friction is the sole source of energy dissipation. The results are supported by the study of simplified joint models which use one-way viscous dampers and purely linear viscous elements to emulate the effects of impact and frictional damping. Author

A88-31600#
COMPARISON OF EXPERIMENTAL TECHNIQUES IN THE MEASUREMENT OF DAMPING CAPACITY OF METAL-MATRIX COMPOSITES
A. K. RAY, G. G. WREN, and V. K. KINRA (Texas A & M University, College Station) IN: The role of damping in vibration and noise control; Proceedings of the Eleventh Biennial Conference on Mechanical Vibration and Noise, Boston, MA, Sept. 27-30, 1987. New York, American Society of Mechanical Engineers, 1987, p. 221-227. Research supported by the Martin Marietta Corp. refs

Structural damping incorporates both material damping and energy dissipation due to macroscopic mechanisms such as joint friction. Numerous experimental techniques have been developed to obtain a measure of damping. However, there has been little distinction in the literature between material and structural damping. This paper discusses two experimental techniques for determining a measure of damping, namely, uniaxial tension-tension fatigue and free-free flexural resonance, and demonstrates that each of these methods measures a different type of damping, namely, material and structural damping, respectively. Author

A88-31605*# Auburn Univ., Ala.
EXPERIMENTAL STUDY OF DAMPING OF GRAPHITE EPOXY COMPOSITE MATERIAL OF THE SPACE TELESCOPE TRUSS SYSTEM
M. D. RAO, M. J. CROCKER (Auburn University, AL), and S. H. GUEST (NASA, Marshall Space Flight Center, Huntsville, AL) IN: The role of damping in vibration and noise control; Proceedings of the Eleventh Biennial Conference on Mechanical Vibration and Noise, Boston, MA, Sept. 27-30, 1987. New York, American Society of Mechanical Engineers, 1987, p. 271-277. refs
(Contract NAS8-36146)

The truss system of the Hubble Space Telescope is made of graphite epoxy tubes and beams that have very low material damping. This paper describes a systematic experimental evaluation of the damping capacity of the graphite epoxy material used in the telescope truss system. The damping capacity of the composite material was measured both under normal and elevated temperatures in atmospheric conditions and in vacuum. Both free decay and steady state methods were used to measure the damping ratio of different specimens under different boundary conditions. A method that involves an iterative least-squares curve-fitting technique for the measured frequency response data has been developed to improve the accuracy of the damping ratio estimation. A unique experimental setup was developed to measure the damping of the material in a vacuum chamber. It was found that outgassing (moisture desorption) has little effect on the damping of the specimen. On the other hand, it was observed that temperature has a significant effect on both the damping and resonance frequencies of the specimen. Author

A88-32145#
EPOS - A FACILITY FOR SIMULATING OPERATIONS NEAR SPACECRAFT [EPOS - EINE ANLAGE ZUR SIMULATION VON OPERATIONEN IM NAHBEREICH VON RAUMFAHRZEUGEN]
G. HEIMBOLD (DFVLR, Oberpfaffenhofen, Federal Republic of Germany) IN: DFVLR, Annual Report 1986. Cologne, Federal Republic of Germany, Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, 1987, p. 85-88. In German.

EPOS (European Proximity Operations Simulation) system, a test bed which is to simulate autonomous rendezvous and docking maneuvers as well as robotics, telemanipulation, and servicing operations in real time and real size, is described. The relative motions of the chaser satellite are represented by an industrial gantry robot with six degrees of freedom. The target rotations are simulated by a three-axis flight simulator. Control of the test bed is maintained by a logical double computer system. C.D.

A88-32178*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EXPERIMENTAL STUDIES OF ACTIVE MEMBERS IN CONTROL OF LARGE SPACE STRUCTURES
J. L. FANSON and J. A. GARBA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 9-17. refs
(Contract NAS7-918)
(AIAA PAPER 88-2207)

Intelligent structures for precision spacecraft applications are structural systems incorporating sensors, actuators, and built-in electronic logic that facilitate self-monitoring of structure responses to disturbances. Attention is presently given to adaptive structures, in which the electronic logic need not be integral to the structure. Active members are used to replace selected passive members of truss-type structures; the sensors employed allow measurement of the elastic strain and deformation experienced by the structure. Two struss-type testbed structures are described. O.C.

A88-32227#
ESTIMATION AND IDENTIFICATION OF NONLINEAR DYNAMIC SYSTEMS
D. JOSEPH MOOK (New York, State University, Buffalo) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 470-478. refs
(AIAA PAPER 88-2271)

A technique is presented for processing noisy state-observable time domain measurements of a nonlinear dynamic system in order to optimally estimate both the state vector trajectory and any model error which may be present. The model error estimate may be subsequently used to accurately identify the parameters in the differential equation model of the nonlinear dynamic system. The method is demonstrated by application to several examples and is shown to be accurate and robust with respect to: (1) large errors in the original assumed differential equation model, including an assumed linear model, (2) low measurement frequency, (3) low measurement accuracy (i.e., large measurement noise), and even (4) low total number of measurements. Author

A88-32264*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE NONLINEAR BEHAVIOR OF A PASSIVE ZERO-SPRING-RATE SUSPENSION SYSTEM
STANLEY E. WOODARD and JERROLD M. HOUSNER (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 884-889.
(AIAA PAPER 88-2316)

Various concepts for advanced syspension systems have been proposed for counteracting gravity loads in ground vibration testing of large space structures. Approximating the flight modes of a low-frequency flexible structure in a ground test requires a very soft suspension system. The dynamic behavior of a passive zero-spring-rate mechanism, sometimes used for such ground testing, is analyzed. This mechanism reduces the stiffness inherent in suspending a test specimen by cables. However, the mechanism is shown to be sensitive to imperfections. Imperfections can initiate nonlinear behavior which becomes more pronounced at lower operating frequencies. Furthermore, large pendular motion of the suspension system couples with the vertical motion, producing additional nonlinearity. Author

A88-32341#
DYNAMICS AND CONTROL OF SPACECRAFT WITH RETARGETTING FLEXIBLE ANTENNAS
LEONARD MEIROVITCH and MOON K. KWAK (Virginia Polytechnic Institute and State University, Blacksburg) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1584-1592. refs
(Contract F33615-86-C-3233)
(AIAA PAPER 88-2414)

This investigation is concerned with the dynamics and control of a spacecraft comprising a rigid platform and a given number of retargetting flexible antennas. The mission consists of maneuvering the antennas so as to coincide with preselected lines of sight while stabilizing the platform in an inertial space and suppressing the elastic vibration of the antennas. The paper contains the derivation of the equations of motion by a Lagrangian approach using quasi-coordinates, as well as a procedure for designing the feedback controls. A numerical example involving a spacecraft consisting of a rigid platform and a single flexible antenna is presented. Author

A88-32362*# Massachusetts Inst. of Tech., Cambridge.
EFFECT OF JOINT DAMPING AND JOINT NONLINEARITY ON THE DYNAMICS OF SPACE STRUCTURES
MARY BOWDEN and JOHN DUGUNDJI (MIT, Cambridge, MA) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1764-1773. Research supported by the McDonnell Douglas Astronautics Co. refs
(Contract NAGW-21)
(AIAA PAPER 88-2480)

Analyses of the effect of linear joint characteristics on the vibrations of a free-free, three-joint beam model show that increasing joint damping increases resonant frequencies and increases modal damping but only to the point where the joint gets 'locked up' by damping. This behavior is different from that predicted by modeling joint damping as proportional damping. Nonlinear analyses of the three-joint model with cubic springs at the joints show all the classical single DOF nonlinear response behavior at each resonance of the multiple DOF system: nondoubling of response for a doubling of forcing amplitude, multiple solutions, jump behavior, and resonant frequency shifts. These properties can be concisely quantified by characteristic backbone curves, which show the locus of resonant peaks for increasing forcing amplitude. Author

A88-32363#
ENHANCEMENT OF FREQUENCY AND DAMPING IN LARGE SPACE STRUCTURES WITH EXTENDABLE MEMBERS
C. T. SUN (Purdue University, West Lafayette, IN) and R. T. WANG IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1774-1780. refs
(AIAA PAPER 88-2482)

The objective of this paper is to investigate the effectiveness of using extendable truss members to tailor the vibrational characteristics of large space structures. In contrast to the conventional control of structures using actuators mounted externally on the structures, the use of extendable truss members makes it possible to vary the control force internally, and, thus, achieve a change in natural frequencies and damping factors. A truss beam is employed as an example to demonstrate the effect of this approach in structural control. Author

N88-10082*# North Carolina Univ., Charlotte. Dept. of Electrical Engineering
DYNAMICS OF SPACECRAFT CONTROL LABORATORY EXPERIMENT (SCOLE) SLEW MANEUVERS Interim Report
Y. P. KAKAD Washington NASA Oct. 1987 43 p
(Contract NAG1-535)
(NASA-CR-4098; NAS 1.26:4098) Avail: NTIS HC A03/MF A01 CSCL 22B

This is the first of two reports on the dynamics and control of slewing maneuvers of the NASA Spacecraft Control Laboratory Experiment (SCOLE). In this report, the dynamics of slewing maneuvers of SCOLE are developed in terms of an arbitrary maneuver about any given axis. The set of dynamical equations incorporate rigid-body slew maneuver and three-dimensional vibrations of the complete assembly comprising the rigid shuttle, the flexible beam, and the reflector with an offset mass. The analysis also includes kinematic nonlinearities of the entire assembly during the maneuver and the dynamics of the interaction between the rigid shuttle and the flexible appendage. The final set of dynamical equations obtained for slewing maneuvers is highly nonlinear and coupled in terms of the flexible modes and the rigid-body modes. The equations are further simplified and evaluated numerically to include the first ten flexible modes and the SCOLE data to yield a model for designing control systems to perform slew maneuvers. Author

N88-10099*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
ATTITUDE CONTROL WORKING GROUP REPORT
DANIEL F. REID (General Electric Co., Philadelphia, Pa.) and PHILLIP A. STUDER *In* NASA-Lewis Research Center, Spacecraft

2000 p 201-232 Jul. 1986
Avail: NTIS HC A11/MF A01 CSCL 22B

The goals were to establish the Attitude Control System (ACS) requirements, constraints, technology assessment, technology shortfalls, expected in the year 2000. These were based upon all missions, military and civil, for LEO and GEO. The critical ACS technology issues were identified and ACS programs developed to address these critical issues. B.G.

N88-10866*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
PREDICTIVE MOMENTUM MANAGEMENT FOR A SPACE STATION MEASUREMENT AND COMPUTATION REQUIREMENTS
JOHN CARL ADAMS Aug. 1986 148 p
(Contract NAS9-17560)
(NASA-CR-172026; NAS 1.26:172026; CSDL-T-926; UPN-906)
Avail: NTIS HC A07/MF A01 CSCL 22B

An analysis is made of the effects of errors and uncertainties in the predicting of disturbance torques on the peak momentum buildup on a space station. Models of the disturbance torques acting on a space station in low Earth orbit are presented, to estimate how accurately they can be predicted. An analysis of the torque and momentum buildup about the pitch axis of the Dual Keel space station configuration is formulated, and a derivation of the Average Torque Equilibrium Attitude (ATEA) is presented, for the case of no MRMS (Mobile Remote Manipulation System) motion, Y vehicle axis MRMS motion, and Z vehicle axis MRMS motion. Results showed the peak momentum buildup to be approximately 20000 N-m-s and to be relatively insensitive to errors in the predicting torque models, for Z axis motion of the MRMS was found to vary significantly with model errors, but not exceed a value of approximately 15000 N-m-s for the Y axis MRMS motion with 1 deg attitude hold error. Minimum peak disturbance momentum was found not to occur at the ATEA angle, but at a slightly smaller angle. However, this minimum peak momentum attitude was found to produce significant disturbance momentum at the end of the predicting time interval. Author

N88-11700*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AEROASSISTED-VEHICLE DESIGN STUDIES FOR A MANNED MARS MISSION
GENE P. MENEES Oct. 1987 16 p
(NASA-TM-100031; A-87356; NAS 1.15:100031) Avail: NTIS HC A03/MF A01 CSCL 22B

An aerobrake design that has matured over several years of development accounting for all of the important flow phenomenology which are characteristic of aerobraking vehicles is proposed as the mission baseline. Flight regimes and aerothermal environments for both Mars and Earth entry are calculated using advanced methods to account for real-gas, thermochemical, relaxation effects. The results are correlated with thermal-protection and structural requirements and mission performance capability. The importance of nonequilibrium radiative heating for Earth aerocapture is demonstrated. It is suggested that two aerobrakes of different sizes will produce optimal performance for the three phases of the mission (i.e., one aerobrake for Mars aerocapture and descent of the surface lander and another for Earth return). Author

N88-11721 TRW Defense and Space Systems Group, Redondo Beach, Calif.
MODELING OF ENVIRONMENTALLY-INDUCED EFFECTS WITHIN SATELLITES. PART 1: NASCAP MODELING OF SATELLITES
N. JOHN STEVENS *In* CNES, Space Environment Technology p 497-510 Apr. 1987
Avail: CEPADUES-Editions, Toulouse, France

The use of the NASCAP computer code to predict the charging of spacecraft surfaces in response to geomagnetic substorm environments is treated. Spacecraft models corresponding to a spin and three-axis stabilized satellite are discussed. The models are run primarily to determine the charge storage in the dielectrics and to locate the possible sites for discharges. The possibility of utilizing expanded NASCAP models to view potential profiles in more detail is illustrated. ESA

N88-11735*# Control Research Corp., Lexington, Mass.
CONTROL DESIGN CHALLENGES OF LARGE SPACE SYSTEMS AND SPACECRAFT CONTROL LABORATORY EXPERIMENT (SCOLE) Final Report
JIGUAN GENE LIN Oct. 1987 71 p
(Contract NAS1-18185)
(NASA-CR-178392; NAS 1.26:178392) Avail: NTIS HC A04/MF A01 CSCL 22B

The quick suppression of the structural vibrations excited by bang-bang (BB) type time-optional slew maneuvers via modal-dashpot design of velocity output feedback control was investigated. Simulation studies were conducted, and modal dashpots were designed for the SCOLE flexible body dynamics. A two-stage approach was proposed for rapid slewing and precision pointing/retargeting of large, flexible space systems: (1) slew the whole system like a rigid body in a minimum time under specified limits on the control moments and forces, and (2) damp out the excited structural vibrations afterwards. This approach was found promising. High-power modal/dashpots can suppress very large vibrations, and can add a desirable amount of active damping to modeled modes. Unmodeled modes can also receive some concomitant active damping, as a benefit of spillover. Results also show that not all BB type rapid pointing maneuvers will excite large structural vibrations. When properly selected small forces (e.g., vernier thrusters) are used to complete the specified slew maneuver in the shortest time, even BB-type maneuvers will excite only small vibrations (e.g., 0.3 ft peak deflection for a 130 ft beam). Author

N88-11740# Tokyo Univ. (Japan). Inst. of Space and Astronautical Science.
ADAPTIVE CONTROL OF LARGE SPACE STRUCTURE (LSS)
YU SHAOHUA Mar. 1987 43 p
(ISAS-R-621; ISSN-0285-6808) Avail: NTIS HC A03/MF A01

A set of closely related topics concerning the methodology of an optimal attitude maneuver control of a satellite with flexible appendages is investigated, i.e., such as a mathematical model of coupled motion, pulse-mode control, optimal and programmed maneuvers, appendage vibration damping through adaptive control and conventional control, and an adaptive identification (deterministic and stochastic) algorithm of time-varying modal coordinate parameters. A distinctive feature of the research was that only the actuators of the central satellite attitude control system were assumed to perform both satellite attitude control and appendage deformation control. Some aspects of interaction between control system characteristics and structure/configuration design parameters are outlined. Author

N88-12534 North Carolina State Univ., Raleigh.
NATURAL CONTROL OF FLEXIBLE SPACE STRUCTURES Ph.D. Thesis
MARK HARRISON MORTON 1987 145 p
Avail: Univ. Microfilms Order No. DA8718909

Families of structural control systems are characterized and the inherent properties that provide the essential motivation behind the theory of Natural Control are revealed. First, the nature of Natural Control and the associated exponential stability characteristics of flexible space structures are described. Next the dynamics of freely non-rotating flexible spacecraft are reviewed and the results extended to rotating flexible spacecraft. Finally, the effect of using a limited number of forces to control the non-rotating spacecraft over the use of distributed control forces is characterized by a change in the magnitude of the control effort and a deterioration in the dynamic performance. Two numerical examples demonstrate the results. Dissert. Abstr.

N88-12535 Virginia Polytechnic Inst. and State Univ., Blacksburg.
NEW FEEDBACK DESIGN METHODOLOGIES FOR LARGE SPACE STRUCTURES: A MULTI-CRITERION OPTIMIZATION APPROACH Ph.D. Thesis
DONG-WON REW 1987 228 p
Avail: Univ. Microfilms Order No. DA8719050

Three new feedback design algorithms are presented: (1) a generalized linear-quadratic regulator (LQR) formulation; (2) a generalized LQR formulation based on Lyapunov stability theorem; and (3) an eigenstructure assignment method using Sylvester's equation. In addition, a noniterative robust eigenstructure assignment algorithm via a projection method is introduced, which produces a fairly well-conditioned eigenvector matrix and provides an excellent starting solution for optimizations of various design criteria. Finally, two sets of numerical examples are adopted: 6th order mass-spring systems and various reduced order models of a flexible system. The numerical results confirm that the use of multi-criterion optimizations by using a minimum correction homotopy technique is a useful tool with significant potential for enhanced computer-aided design of control systems. The robust eigenstructure assignment algorithm is implemented and tested for a 24th reduced order model, which establishes the approach to be applicable to systems of at least moderate dimensionality. It is shown analytically and computationally that constraining closed-loop eigenvectors to equal open-loop eigenvectors generally does not lead to either optimal conditioning (robustness) of the closed-loop eigenvectors or minimum gain norm. Dissert. Abstr.

N88-12817*# North Carolina Univ., Charlotte. Dept. of Electrical Engineering.
COMBINED PROBLEM OF SLEW MANEUVER CONTROL AND VIBRATION SUPPRESSION
Y. P. KAKAD 1987 11 p
(Contract NAG1-535)
(NASA-CR-181537; NAS 1.26:181537) Avail: NTIS HC A03/MF A01 CSCL 20K

The combined problem of slew maneuver control and vibration suppression of NASA Spacecraft Control Laboratory Experiment (SCOLE) is considered. The coupling between the rigid body modes and the flexible modes together with the effect of the control forces on the flexible antenna is discussed. The nonlinearities in the equations are studied in terms of slew maneuver angular velocities. Author

N88-13374*# Massachusetts Inst. of Tech., Cambridge.
SURVEY ON LARGE SCALE SYSTEM CONTROL METHODS
MATHIEU MERCADAL 1987 20 p
(Contract NAG1-126)
(NASA-CR-181556; NAS 1.26:181556) Avail: NTIS HC A03/MF A01 CSCL 22B

The problem inherent to large scale systems such as power network, communication network and economic or ecological systems were studied. The increase in size and flexibility of future spacecraft has put those dynamical systems into the category of large scale systems, and tools specific to the class of large systems are being sought to design control systems that can guarantee more stability and better performance. Among several survey papers, reference was found to a thorough investigation on decentralized control methods. Especially helpful was the classification made of the different existing approaches to deal with large scale systems. A very similar classification is used, even though the papers surveyed are somehow different from the ones reviewed in other papers. Special attention is brought to the applicability of the existing methods to controlling large mechanical systems like large space structures. Some recent developments are added to this survey. Author

N88-13376# Illinois Univ., Urbana. Decision and Control Lab.
DESIGN OF LOW ORDER CONTROLLERS FOR ROBUST DISTURBANCE REJECTION IN LARGE SPACE STRUCTURES M.S. Thesis
RUSSELL A. RAMAKER Sep. 1987 67 p
(Contract N00014-84-C-0149)
(AD-A185202; DC-97; UILU-ENG-87-2260) Avail: NTIS HC A04/MF A01 CSCL 09A

This thesis will investigate several issues relating to the objective of improving the disturbance rejection of a Large Space Structure (LSS) type system. Due to properties of LSS systems, the design of the controller must address three main issues: 1) improving of the disturbance rejection properties of the system; 2) insuring that the controller is robust to modeling uncertainty; and 3) implementing the design as a low order output feedback controller. The disturbance rejection of the system will be quantified using the H-norm. An arbitrary level of disturbance rejection will then be achieved through a Linear Quadratic (LQ) minimization. This LQ solution produces a state feedback controller which is robust to modeling uncertainty. In order to realize this design, a low order output feedback controller will be designed based on the LQ solution using projective controls. The method described in this thesis will then be applied to a 40th order LSS example. Using a decentralized approach, a controller will be designed which satisfies the issues discussed above. GRA

N88-13907*# Catholic Univ. of America, Washington, D.C. Dept. of Electrical Engineering.
OPTIMAL CONTROL OF LARGE SPACE STRUCTURES VIA GENERALIZED INVERSE MATRIX
CHARLES C. NGUYEN and XIAOWEN FANG 1987 5 p
(Contract NAG5-949)
(NASA-CR-182336; NAS 1.26:182336) Avail: NTIS HC A02/MF A01 CSCL 09B

Independent Modal Space Control (IMSC) is a control scheme that decouples the space structure into n independent second-order subsystems according to n controlled modes and controls each mode independently. It is well-known that the IMSC eliminates control and observation spillover caused when the conventional coupled modal control scheme is employed. The independent control of each mode requires that the number of actuators be equal to the number of modelled modes, which is very high for a faithful modeling of large space structures. A control scheme is proposed that allows one to use a reduced number of actuators to control all modeled modes suboptimally. In particular, the method of generalized inverse matrices is employed to implement the actuators such that the eigenvalues of the closed-loop system are as closed as possible to those specified by the optimal IMSC. Computer simulation of the proposed control scheme on a simply supported beam is given. Author

N88-14866*# Texas A&M Univ., College Station. Dept. of Mechanical Engineering.
ACTIVE CONTROL OF FLEXURAL VIBRATIONS IN BEAMS Final Report
CARL H. GERHOLD *In* NASA. Lyndon B. Johnson Space Center, Houston, Tex. NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 1 20 p Nov. 1987
Avail: NTIS HC A15/MF A01 CSCL 20K

The feasibility of using piezoelectric actuators to control the flexural oscillations of large structures in space is investigated. Flexural oscillations are excited by impulsive loads. The vibratory response can degrade the pointing accuracy of cameras and antennae, and can cause high stresses at structural node points. Piezoelectric actuators have the advantage of exerting localized bending moments. In this way, vibration is controlled without exciting rigid body modes. The actuators are used in collocated sensor/driver pairs to form a feedback control system. The sensor produces a voltage that is proportional to the dynamic stress at the sensor location, and the driver produces a force that is proportional to the voltage applied to it. The analog control system amplifies and phase shifts the sensor signal to produce the voltage signal that is applied to the driver. The feedback control is demonstrated to increase the first mode damping in a cantilever beam by up to 100 percent, depending on the amplifier gain. The damping efficiency of the control system when the piezoelectrics

are not optimally positioned at points of high stress in the beam is evaluated. Author

N88-14872*# Michigan Technological Univ., Houghton. Dept. of Mechanical Engineering/Engineering Mechanics.
DYNAMICS FORMULATIONS FOR THE REAL-TIME SIMULATION OF CONSTRAINED MOTION Final Report
FREDERICK A. KELLY *In* NASA, Lyndon B. Johnson Space Center, Houston, Tex. NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 1 20 p Nov. 1987
Avail: NTIS HC A15/MF A01 CSCL 20C

The Space Shuttle program has relied heavily on simulation throughout all phases of development and operation. Real-time, man-in-the-loop simulation has served the NASA manned space flight program by providing the means to evaluate systems design and integrated systems performance in a simulated flight environment as well as provide a means to train flight crews. New challenges are presented by the development and operation of a permanently manned space station. The assembly of the space station, the transferral of payloads and the use of the space station manipulator to berth the Orbiter are operations critical to the success of the space station. All these operations are examples of constrained motion among the bodies associated with the Orbiter and space station system. The state of the art of formulating the governing dynamical equations of motion for constrained systems are described. The uses of the two basic problems in multibody dynamics are discussed. The most efficient formulations of the equations of motion are addressed from the point of view of completeness. The issues surrounding incorporating the constraints into the equation of motion are presented. Author

N88-15825# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
DOCKING/BERTHING SUBSYSTEM (DBS). DEVELOPMENT PART 1: LATCHING ANALYSIS Final Report
Paris, France ESA 27 Jul. 1987 127 p Revised Prepared in cooperation with Societe Anonyme Belge de Constructions Aeronautiques, Brussels, Belgium, and Senei S.A., Madrid, Spain
(Contract ESTEC-6409/85-NL-AN(SC))
(ESA-CR(P)-2479; ETN-88-91425) Avail: NTIS HC A07/MF A01

Based on a low impact docking concept and a latching mechanism concept, a docking/berthing subsystem and its operations were defined. A set of four breadboard models of the latch were manufactured and docking tests were performed on a four degree of freedom air bearing table. The tests demonstrate feasibility of the low impact docking concept under the test facility conditions. ESA

N88-16060*# Photon Research Associates, Inc., Cambridge, Mass.
LARGE-ANGLE SLEWING MANEUVERS FOR FLEXIBLE SPACECRAFT Final Report
HON M. CHUN and JAMES D. TURNER Washington NASA Feb. 1988 88 p
(Contract NAS1-18098)
(NASA-CR-4123; CR-R-016; NAS 1.26:4123) Avail: NTIS HC A05/MF A01 CSCL 22B

A new class of closed-form solutions for finite-time linear-quadratic optimal control problems is presented. The solutions involve Potter's solution for the differential matrix Riccati equation, which assumes the form of a steady-state plus transient form. Illustrative examples are presented which show that the new solutions are more computationally efficient than alternative solutions based on the state transition matrix. As an application of the closed-form solutions, the neighboring extremal path problem is presented for a spacecraft retargeting maneuver where a perturbed plant with off-nominal boundary conditions now follows a neighboring optimal trajectory. The perturbation feedback approach is further applied to three-dimensional slewing maneuvers of large flexible spacecraft. For this problem, the nominal solution is the optimal three-dimensional rigid body slew. The perturbation feedback then limits the deviations from this nominal solution due to the flexible body effects. The use of frequency shaping in both the nominal and perturbation feedback formulations reduces the excitation of high-frequency unmodeled modes. A modified Kalman filter is presented for estimating the plant states. Author

N88-16099# Joint Publications Research Service, Arlington, Va.
GYROSTABILIZER SYSTEM OF KVANT MODULE
N. SHEREMETYEVSKIY and B. CHERTOK *In its* JPRS Report: Science and Technology. USSR: Space p 99-100 24 Nov. 1987 Transl. into ENGLISH from Pravda (Moscow, USSR), 6 Sep. 1987 p 3
Avail: NTIS HC A08/MF A01

The development and features of the system used to control the rotary motion of the space complex, Mir, and orient it precisely during astronomical observations with equipment of the Kvant module are examined. This system allows the complex to be stabilized with a precision of one minute of arc. The system is said to include high precision angular velocity meters, inertial sensors of angular position, an onboard computer complex with a modular structure, and powered gyroscopes (gyrodynes on a magnetic suspension) which function as drive motors. Development of gyrodynes for the Kvant module involved mathematical modeling of electromagnetic, dynamic and thermal processes. Mathematical modeling also indicated the necessity of a special system of spatial arrangement for six gyrodynes on the module and was used to prepare highly complex algorithms for the control system's computer. These algorithms take into account maintenance of the system's controllability in any type of orientation of the Mir complex, and also while the gyrodynes are being put into their initial state, using only a gravitational system which conserves power sources. Author

N88-16803# Consulenze Generali Roma (Italy).
ANALYTICAL INTERACTIVE APPROACH FOR PHENOMENA INVOLVING STRUCTURES, THERMAL AND CONTROL ASPECTS. VOLUME 1: THEORY Final Report
C. ARDUINI, G. FUSCO, and S. SGUBINI Paris, France ESA Dec. 1985 347 p
(Contract ESTEC-5485/83-NL-PB(SC))
(ESA-CR(P)-2503-VOL-1; ETN-88-91205) Avail: NTIS HC A15/MF A01

The problem of producing comprehensive equations for describing the thermostructural fully interactive behavior of uni- and bi-dimensional elements (like beams, plates, shells) was studied. Ways of assembling these elements together, and with mechanical and thermal control devices were investigated. Conduction theory; radiative inputs (the shadow problem); elastic, inertial, and thermal loads; and interface constraints and assembly of elements are discussed. ESA

N88-16804# Consulenze Generali Roma (Italy).
ANALYTICAL INTERACTIVE APPROACH FOR PHENOMENA INVOLVING STRUCTURES, THERMAL, AND CONTROL ASPECTS. VOLUME 2: TOWARD THE SOLUTION Final Report
C. ARDUINI, G. FUSCO, and S. SGUBINI Paris, France ESA Dec. 1985 266 p
(Contract ESTEC-5485/83-NL-PB(SC))
(ESA-CR(P)-2503-VOL-2; ETN-88-91206) Avail: NTIS HC A12/MF A01

The problem of producing comprehensive equations for describing the thermostructural fully interactive behavior of uni and bidimensional elements (like beams, plates, shells) was studied. Ways of assembling these elements together, and with mechanical and thermal control devices were investigated. Methods for problems in the space domain of interactive problems are outlined. Examples of heat inputs and shadows; thermal problems; thermoelastic problems; and structure control interaction are shown. ESA

N88-16805# Consulenze Generali Roma (Italy).
ANALYTICAL INTERACTIVE APPROACH FOR PHENOMENA INVOLVING STRUCTURES, THERMAL, AND CONTROL ASPECTS. VOLUME 3: EXECUTIVE SUMMARY Final Report

C. ARDUINI, G. FUSCO, and S. SGUBINI Paris, France ESA Dec. 1985 67 p
(Contract ESTEC-5485/83-NL-PB(SC))
(ESA-CR(P)-2503-VOL-2; ETN-88-91211) Avail: NTIS HC A04/MF A01

The problem of producing comprehensive equations for describing the thermostructural fully interactive behavior of uni and bidimensional elements (like beams, plates, shells) was studied. Ways of assembling these elements together, and with mechanical and thermal control devices were investigated. ESA

N88-17223*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
DEVELOPMENT OF A COUPLED EXPERT SYSTEM FOR THE SPACECRAFT ATTITUDE CONTROL PROBLEM
K. KAWAMURA, G. BEALE, J. SCHAFFER, B.-J. HSIEH, S. PADALKAR, J. RODRIGUEZMOSCOSO (Vanderbilt Univ., Nashville, Tenn.), F. VINZ, and K. FERNANDEZ *In* NASA. Lyndon B. Johnson Space Center, Houston, Texas. First Annual Workshop on Space Operations Automation and Robotics (SOAR 87) p 125-132 Oct. 1987
Avail: NTIS HC A23/MF A01 CSCL 22B

A majority of the current expert systems focus on the symbolic-oriented logic and inference mechanisms of artificial intelligence (AI). Common rule-based systems employ empirical associations and are not well suited to deal with problems often arising in engineering. Described is a prototype expert system which combines both symbolic and numeric computing. The expert system's configuration is presented and its application to a spacecraft attitude control problem is discussed. Author

N88-17719# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany). Dept. for Ariane and Launcher Systems.
RENDEZVOUS AND DOCKING VERIFICATION AND DEMONSTRATION IN ORBIT, EXECUTIVE SUMMARY
A. GETZSCHMANN and D. GRIMBERT (MATRA Espace, Toulouse, France) Paris, France ESA Dec. 1986 120 p
(Contract ESA-6492/85-NL-AN(SC))
(MBB-303-16/86; ESA-CR(P)-2487;
MBB-RVD-RVDV-SVS-REP-ERNO-01; ETN-88-91700) Avail: NTIS HC A06/MF A01

The feasibility of a rendezvous and docking (RVD) mission in LEO using EURECA, to demonstrate an LEO dedicated RVD concept and for geostationary RVD demonstration in LEO was analyzed. Adequate verification methods for all RVD equipment and functions were identified. The purpose and logic of the ground test facilities within the development and verification phase of the RVD equipment and functions are outlined. The distinction between verification and validation is emphasized. Verification is concerned with all activities which prove that a design or performance feature is in accordance with a specification. Validation activities prove that the item or process is compatible with the reality, which includes to a certain extent also a verification of the specification. The demonstration mission constraints were identified and a mission timetable was established. ESA

N88-18616# Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil).
CONSTRUCTION ASPECTS OF TESTBEDS FOH ATTITUDE CONTROL SYSTEMS SIMULATION OF ARTIFICIAL SATELLITES [ASPECTOS CONSTRUTIVOS DE BANCADAS PARA SIMULACAO DE SISTEMAS DE CONTROLE DE ATITUDE DE SATELITES ARTIFICAIS]
AGENOR T. FLEURY, PETRONIO NDESOUZA, and L. VICTOR C. CARDIERI Aug. 1987 6 p In PORTUGUESE; ENGLISH summary Presented at the 9th Brazilian Congress of Mechanical Engineering, Florianopolis, Santa Catarina, 7-11 Dec. 1987
(INPE-4283-PRE/1155) Avail: NTIS HC A02/MF A01

This work presents the basic aspects concerning the construction of two test beds for satellite Attitude and Orbit Control Systems (AOCS) hardware-in-the-loop tests. The main goal to be reached with these test beds is the fast accomplishment of laboratory results in the various phaese of an AOCS development, from its initial conceptual definition to a prequalification phase. The central equipment of these test beds consists of a one-degree-of-freedom air bearing table and a two-degree-of-freedom servo rate table. Various AOCS components such as reaction wheels, cold gas jet propulsion system, telemetry/telecommand system and celestial simulators were also developed at INPE. The designs of the test beds as integrated equipments are presented. The main performance parameters and associated experimental results are presented and discussed as well. Author

N88-19488# European Space Agency. European Space Operations Center, Darmstadt (West Germany).
SAFE AND FUEL MINIMUM REFERENCE TRAJECTORIES FOR CLOSED LOOP CONTROLLED APPROACHES
F. HECHLER *In its* Proceedings of the 1st European In-Orbit Operations Technology Symposium p 19-28 Nov. 1987
Avail: NTIS HC A21/MF A01

A method for the determination of minimum time and delta-V orbit control strategies for the transfer of a chaser to a docking port on the V bar axis of a target is proposed under the assumption that the relative motion is described by the Clohessy-Wiltshire equations. Safety considerations in the design of the control are investigated. Forced motions along straight lines are investigated. It is shown that linear optimization methods can compute generalized minimum delta-V and safe orbit control strategies that protect the target from collision if the chaser is running out of control. Constraints on maneuver times, on the permissible trajectory region, and on the thrust level can be incorporated into the solution. ESA

N88-19489# TRW Space Technology Labs., Redondo Beach, Calif.
COST-EFFECTIVE ORBIT TRANSFER MODES FOR SATELLITE RETRIEVAL AND SERVICING
HANS E. MEISSINGER *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 29-35 Nov. 1987
Avail: NTIS HC A21/MF A01

Access for servicing, from the Space Station to satellites flying at similar or different orbital altitudes; limitations in accessibility due to differential nodal regression between the orbits in question; avoidance of high delta-V expenditures for plane change maneuvers, and the orbit transfer alternatives of retrieving a satellite from higher orbit for servicing at the station or shuttle versus in situ servicing at the satellite orbit altitude by using an orbital maneuvering vehicle carrying a telerobotic servicer and the necessary replacement parts are discussed. Scenarios that promise large cost savings through reduced propellant-to-orbit transportation charges as well as other mission operation expenditures are considered. Natural orbit evolution factors often can be exploited to provide those benefits. The cumulative savings are projected to amount to tens of millions of dollars per year. ESA

N88-19494# Societe Nationale Industrielle Aerospatiale, Cannes (France).
ANALYSIS OF RVD OPERATIONS IN MANNED SPACE MISSIONS
P. MAUTE, H. P. NGUYEN, and W. FEHSE (European Space Agency, European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 73-86 Nov. 1987
Avail: NTIS HC A21/MF A01

A rendezvous and docking operations concept for manned missions, taking into account man-induced constraints as well as human capabilities, is defined for Man Tended Free Flyer servicing by Hermes as reference mission. Simulation tools used for man in the loop capabilities assessment are presented and performances are summarized. A sequence of events is worked out according to operations constraints (ground link, collision avoidance, ergonomy) for the nominal as well as for the back-up cases. ESA

N88-19514# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
MOTION SIMULATION FOR IN-ORBIT OPERATIONS
W. FEHSE and R. H. BENTALL. *In its* Proceedings of the 1st European In-Orbit Operations Technology Symposium p 263-271 Nov. 1987
Avail: NTIS HC A21/MF A01

Simulation of spaceborne proximity operations such as rendezvous and docking, robotics, telemanipulation, and other servicing operations is discussed. Simulation techniques suitable for dynamic systems analysis, including physical simulations, computer simulations and computer-driven and dynamic simulations are reviewed. The role of the various types of simulation in the definition, development, and verification of an in-orbit operations system are described using the example of a development program for rendezvous and docking. ESA

N88-19516# MATRA Espace, Paris-Velizy (France).
DYNAMIC TESTING OF A DOCKING SYSTEM
D. GRIMBERT and P. MARCHAL (Centre National d'Etudes Spatiales, Toulouse, France) *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 281-288 Nov. 1987
(Contract CNES-640/85; CNES-640/86)
Avail: NTIS HC A21/MF A01

In order to examine docking in real hardware on the ground, a test bench which recreates the zero-g dynamic environment of the docking system was developed. It uses a 6 degree-of-freedom motion simulator and computed dynamics issued from contact force measurements. A functional prototype of a docking system was built, and implemented on the docking facility. The tests performed will validate the bench capability and give preliminary information about the docking process. Hardware developed and the test objectives, including immediate experimentation on docking dynamics and future extension to a docking simulation within its complete RVD environment, are described. ESA

N88-19520# University Coll., London (England).
COVARIANT CONTROL OF BILATERAL SERVOS FOR IN-ORBIT MANIPULATION
J. E. E. SHARPE and K. V. SILVA (United Kingdom Atomic Energy Authority, Harwell, England) *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 317-323 Nov. 1987 Sponsored by Farrey Engineering Ltd.
Avail: NTIS HC A21/MF A01

A class of covariant bilateral force reflecting systems for teleoperation that enables the operator to use sensory feel to control the slave with a total transmission delay of 200 msec is introduced. The prototype 3 kWe electrohydraulic master-slave system has a forward positional bandwidth of 20 Hz and is capable of positioning a mass of 4 kg flexibly supported at 0.75 m radius at a slew rate of 200 deg/sec. The reflected sensory force has a bandwidth greater than 250 Hz. Experimental evidence shows the master-slave system to appear transparent to the operator within the normal positional bandwidth. The operators therefore feel that they are directly swinging the load mass at the end of a flexible rod and are able to control the vibrations of the rod. This is not possible with simple positional control as the resonant system is outside the control loop. The operator uses the high frequency sensory information in an adaptive manner. However, with the transmission delay it is necessary to reduce the sensory force gain to obtain stability. ESA

N88-19531# Erno Raumfahrttechnik G.m.b.H., Bremen (West Germany).
RENDEZVOUS AND DOCKING (RVD) VERIFICATION AND DEMONSTRATION IN-ORBIT
A. GETZSCHMANN, B. CLAUDINON, W. FEHSE, and H.-P. NGUYEN (Societe Nationale Industrielle Aerospatiale, Blagnac, France) *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 405-418 Nov. 1987
Avail: NTIS HC A21/MF A01

An overall verification concept for a space RVD system and its elements was derived. The concept takes into account the verification objectives at all levels (system, subsystem, equipment), the possible ground tests and available test facilities, and the potential of on-orbit tests up to a complete demonstration mission with two spacecraft. The results reveal that verification activities can be done mostly on ground. For validation and demonstration purposes in orbit tests are recommended. An RVD demonstration mission is presented as well as the impact on the spacecraft due to RVD operations, considering two EURECA vehicles. ESA

N88-19572# Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil).
SIMULATION AND TESTS OF A SATELLITE ATTITUDE AND ORBIT CONTROL SYSTEM. GENERAL CONSIDERATIONS CONCERNING AN EXAMPLE CASE (INPE) AND DESIGN OF A SERVO RATE TABLE [SIMULACAO E TESTES DE SISTEMAS DE CONTROLE DE ATITUDE E ORBITA DE SATELITE CONSIDERACOES GERAIS SOBRE UM CASE EXEMPLO (INPE)E PROJETOS DE UMA MESA DE ROTACAO CONTROLADA]
AGENOR DET. FLEURY, PETRONIO N. DESOUZA, GILBERTO DAC. TRIVELATO, [illegible] TAIR A. FERRARESI, and JOSE F. RIBEIRO Aug. 1987 11 p In PORTUGUESE; ENGLISH summary Submitted for publication
(INPE-4282-PRE/1154) Avail: NTIS HC A03/MF A01

The Attitude and Orbital Control System (AOCS) is a basic component of a satellite. In order to guarantee the correct performance of the AOCS, exhaustive testing has to be done in a laboratory, both at component and at system level. This work intends to present first the implementation of an AOCS Simulation Laboratory by INPE's Space Mechanics and Control Department, as an example case, briefly showing the technological results already accomplished. It presents as well the basic aspects related to design, manufacture, and tests of a one degree-of-freedom servo rate table. It also describes, at an introductory level, the design of a second controlled axis for the table. Author

N88-19575*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AEROASSISTED ORBIT TRANSFER VEHICLE TRAJECTORY ANALYSIS
ROBERT D. BRAUN and WILLIAM T. SUIT Jan. 1988 21 p
(NASA-TM-89139; NAS 1.15:89139) Avail: NTIS HC A03/MF A01 CSCL 22A

The emphasis in this study was on the use of multiple pass trajectories for aerobraking. However, for comparison, single pass trajectories, trajectories using ballutes, and trajectories corrupted by atmospheric anomolies were run. A two-pass trajectory was chosen to determine the relation between sensitivity to errors and payload to orbit. Trajectories that used only aerodynamic forces for maneuvering could put more weight into the target orbits but were very sensitive to variations from the planned trajectors. Using some thrust control resulted in less payload to orbit, but greatly reduced the sensitivity to variations from nominal trajectories. When compared to the non-thrusting trajectories investigated, the judicious use of thrusting resulted in multiple pass trajectories that gave 97 percent of the payload to orbit with almost none of the sensitivity to variations from the nominal. Author

07

POWER

Includes descriptions of analyses, systems, and trade studies of electric power generation, storage, conditioning and distribution.

A88-11134#
SOLAR RECEIVER FOR THE SPACE STATION BRAYTON ENGINE

HAL J. STRUMPF and MURRAY G. COOMBS (AiResearch Manufacturing Co., Torrance, CA) ASME, International Gas Turbine Conference and Exhibition, 32nd, Anaheim, CA, May 31-June 4, 1987. 8 p.
(ASME PAPER 87-GT-252)

A study has been conducted on the preliminary design and development of a solar receiver to be used for electrical power production in a closed Brayton cycle engine on the Space Station. The receiver incorporates integral thermal storage, using a eutectic mixture of LiF and CaF2 as the thermal-storage solid-to-liquid phase-change material. The thermal storage is required to enable power production during the substantial LEO eclipse period.
Author

A88-11776
IECEC '87; PROCEEDINGS OF THE TWENTY-SECOND INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, PHILADELPHIA, PA, AUG. 10-14, 1987. VOLUMES 1, 2, 3, & 4
Conference sponsored by AIAA, ACHS, SAE, et al. New York, American Institute of Aeronautics and Astronautics, 1987, p. Vol. 1, 623 p.; vol. 2, 601 p.; vol. 3, 500 p.; vol. 4, 519 p. For individual items see A88-11777 to A88-12012.

Papers are presented on space power requirements and issues, space photovoltaic systems, space solar dynamic systems, space thermal systems, manned and unmanned space power systems, thermionics, and thermoelectrics. Also considered are high power devices for space power systems, high power conversion for space power systems, 1-10 kWe nuclear space power sources, 100-kW class nuclear power concepts, space reactor safety, and multimegawatt space nuclear power systems. Other topics include space power systems automation, space kilovolt technology, space power electronics, space lithium and nickel-cadmium batteries, lithium sodium storage, and space fuel cells. Papers are also presented on space nickel hydrogen batteries, alternative energy concepts and fuels, fuel cell technology, flow batteries, high-temperature batteries, energy conservation, battery energy storage, thermal energy storage, heat engines, MHD power systems, nuclear fission, and the Stirling cycle.
R.R.

A88-11782*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
SPACE STATION ELECTRIC POWER SYSTEM REQUIREMENTS AND DESIGN
FRED TEREN (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 39-47. Previously announced in STAR as N87-22001.

An overview of the conceptual definition and design of the Space Station Electric Power System (EPS) is given. Responsibilities for the design and development of the EPS are defined. The EPS requirements are listed and discussed, including average and peak power requirements, contingency requirements, and fault tolerance. The most significant Phase B trade study results are summarized, and the design selections and rationale are given. Finally, the power management and distribution system architecture is presented.
Author

A88-11793*# TRW, Inc., Redondo Beach, Calif.
ADVANCED PHOTOVOLTAIC SOLAR ARRAY DESIGN
RICHARD KURLAND (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) and PAUL STELLA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 103-114. refs
(Contract JPL-957358)

An ultralightweight flexible-blanket fistpack, foldout solar array design is defined. The design establishes a critical intermediate milestone of the NASA high-performance Advanced Photovoltaic Solar Array program through its primary objective of realistically demonstrating a solar array that can provide greater than 130 W/kg at beginning of life (BOL) and 100 W/kg at end of life for a 10-year geosynchronous 10-kW (BOL) space power system. This paper reviews the critical features of the preliminary design and the implications for long-term array technology development.
Author

A88-11794*# Sundstrand Corp., Rockford, Ill.
TOLUENE STABILITY SPACE STATION RANKINE POWER SYSTEM
V. N. HAVENS, D. R. RAGALLER, L. SIBERT (Sundstrand Corp., Rockford, ILL) and D. MILLER (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 121-126. refs

A dynamic test loop is designed to evaluate the thermal stability of an organic Rankine cycle working fluid, toluene, for potential application to the Space Station power conversion unit. Samples of the noncondensible gases and the liquid toluene were taken periodically during the 3410 hour test at 750 F peak temperature. The results obtained from the toluene stability loop verify that toluene degradation will not lead to a loss of performance over the 30-year Space Station mission life requirement. The identity of the degradation products and the low rates of formation were as expected from toluene capsule test data.
Author

A88-11795#
BINARY MERCURY/ORGANIC RANKINE CYCLE POWER SYSTEMS
ALLEN FOX, J. F. LOUIS (MIT, Cambridge, MA), W. J. GREENLEE, and G. H. PARKER (Sundstrand Corp., Rockford, IL) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 127-132. refs

Binary mercury/organic Rankine systems have been assessed for application to compact space power systems, and have been shown to have the potential to attain cycle efficiencies greater than 40 percent. The efficiency is found to be more sensitive to maximum and minimum cycle temperatures than to the temperature at which heat is transferred from the mercury cycle to the toluene cycle. The specific mass is shown to depend primarily on the solar receiver and heat rejection radiator masses, and to have a minimum of between 62 and 40 kg/kWe. It is noted that the cycle can also be used in a cogeneration mode to provide thermal heat at constant temperature levels between 375 and 1000 K.
R.R.

A88-11797#
ROSS-STIRLING ENGINE - A HIGH PERFORMANCE DYNAMIC SPACE POWER SYSTEM
GRAHAM WALKER (Calgary, University, Canada) and STEVEN ZYLSTRA (General Pneumatics Corp., Western Research Center, Scottsdale, AZ) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 138-144. refs

Space power systems and systems requirements are considered, and a Ross-Stirling engine incorporating refractory metals for the hot parts is discussed in detail. The proposed engine would use helium as the working fluid, and would operate at relatively high pressures and speeds to achieve high power densities and compact form. Ross linkages are included in the engine to eliminate piston side forces, permitting an easily-balanced engine arrangement. Multiple cylindrical arrangements are possible wherein a small number of components can be assembled into a family of dynamic space power systems covering a wide power range.
R.R.

A88-11798*# Rockwell International Corp., Canoga Park, Calif.
ADVANCED SPACE SOLAR DYNAMIC POWER SYSTEMS BEYOND IOC SPACE STATION
WAYNE E. WALLIN (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) and MILES O. DUSTIN (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 145-155. refs
(Contract NAS3-24864)

Three different solar dynamic power cycle systems were evaluated for application to missions projected beyond the IOC Space Station. All three systems were found to be superior to two photovoltaic systems (a planar silicon array and a GaAs concentrator array), with both lower weight and area. The alkali-metal Rankine cycle was eliminated from consideration due to low performance, and the Stirling cycle was found to be superior to the closed Brayton cycle in both weight and area. LiF salt, which establishes peak cycle temperatures for both of the considered cycles at about 1090 K, was shown to be the most suitable material for Thermal Energy Storage. R.R.

A88-11799*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SOLAR CONCENTRATOR ADVANCED DEVELOPMENT PROJECT
ROBERT D. CORRIGAN (NASA, Lewis Research Center, Cleveland, OH) and DERIK T. EHRESMAN (Harris Corp., Melbourne, FL) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 156-161.

A solar dynamic concentrator design developed for use with a solar-thermodynamic power generation module intended for the Space Station is considered. The truss hexagonal panel reflector uses a modular design approach and is flexible in attainable flux profiles and assembly techniques. Preliminary structural, thermal, and optical analysis results are discussed. Accuracy of the surface reflectors should be within 5 mrad rms slope error, resulting in the need for close fabrication tolerances. Significant fabrication issues to be addressed include the facet reflective and protective coating processes and the surface specularity requirements. R.R.

A88-11800*# Sanders Associates, Inc., Nashua, N. H.
ADVANCED SOLAR RECEIVER CONCEPTUAL DESIGN STUDY
J. B. KESSELI (Sanders Associates, Inc., Nashua, NH) and D. E. LACY (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 162-168. refs

High temperature solar dynamic Brayton and Stirling receivers are investigated as candidate electrical power generating systems for future LEO missions. These receivers are smaller and more efficient than conventional receivers, and they offer less structural complexity and fewer thermal stress problems. Use of the advanced Direct Absorption Storage Receiver allows many of the problems associated with working with high-volumetric-change phase-change materials to be avoided. A specific mass reduction of about 1/3 with respect to the baseline receiver has been realized. R.R.

A88-11801*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SELECTION OF HIGH TEMPERATURE THERMAL ENERGY STORAGE MATERIALS FOR ADVANCED SOLAR DYNAMIC SPACE POWER SYSTEMS
DOVIE E. LACY, CAROLYN COLES-HAMILTON, and ALBERT JUHASZ (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 169-174. Previously announced in STAR as N87-22174. refs

Under the direction of NASA's Office of Aeronautics and Technology (OAST), the NASA Lewis Research Center has initiated an in-house thermal energy storage program to identify combinations of phase change thermal energy storage media for use with a Brayton and Stirling Advanced Solar Dynamic (ASD) space power system operating between 1070 and 1400 K. A study has been initiated to determine suitable combinations of thermal energy storage (TES) phase change materials (PCM) that result in the smallest and lightest weight ASD power system possible. To date the heats of fusion of several fluoride salt mixtures with melting points greater than 1025 K have been verified experimentally. The study has indicated that these salt systems produce large ASD systems because of their inherent low thermal conductivity and low density. It is desirable to have PCMs with high densities and high thermal conductivities. Therefore, alternate phase change materials based on metallic alloy systems are also being considered as possible TES candidates for future ASD space power systems. Author

A88-11802#
OPTIMIZATION AND ANALYSIS OF LITHIUM HYDRIDE THERMAL ENERGY STORAGE DEVICE CONFIGURATIONS FOR SPACE POWER APPLICATIONS
MOSHE SIMAN-TOV, PAUL WILLIAMS, and MITCHELL OLSZEWSKI (Oak Ridge National Laboratory, TN) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 175-182. refs
(Contract DE-AC05-84OR-21400)

Most of the power required for space-based defense systems is needed during only a short period of the orbital cycle, raising the possibility that the radiator size and mass can be reduced by including a thermal energy storage (TES) component in the heat rejection system. This paper presents the results of thermal performance analysis and optimization of five heat sink TES configurations using LiH as the storage medium. System performance was calculated for a wide range of parameters, including the effects of the prespecified internal void, enhanced thermal conductivity, and internal fins. Masses of storage materials, encapsulating shells, and containment vessels were determined to give total system operational energy storage and power densities. The results show LiH-based TES systems can provide system energy and power densities ranging from 4 to 5 MJ/kg and 12 to 17 kW/kg, respectively. I.S.

A88-11805*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
IMPACT OF THERMAL ENERGY STORAGE PROPERTIES ON SOLAR DYNAMIC SPACE POWER CONVERSION SYSTEM MASS
ALBERT J. JUHASZ, CAROLYN E. COLES-HAMILTON, and DOVIE E. LACY (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 202-207. Previously announced in STAR as N87-22802.

A 16 parameter solar concentrator/heat receiver mass model is used in conjunction with Stirling and Brayton Power Conversion System (PCS) performance and mass computer codes to determine the effect of thermal energy storage (TES) material property changes on overall PCS mass as a function of steady state electrical power output. Included in the PCS mass model are component masses as a function of thermal power for: concentrator, heat receiver, heat exchangers (source unless integral with heat receiver, heat sink, regenerator), heat engine units with optional parallel redundancy, power conditioning and control (PC and C), PC and C radiator, main radiator, and structure. Critical TES properties are: melting temperature, heat of fusion,

density of the liquid phase, and the ratio of solid-to-liquid density. Preliminary results indicate that even though overall system efficiency increases with TES melting temperature up to 1400 K for concentrator surface accuracies of 1 mrad or better, reductions in the overall system mass beyond that achievable with lithium fluoride (LiF) can be accomplished only if the heat of fusion is at least 800 kJ/kg and the liquid density is comparable to that of LiF (1800 kg/cu m). Author

A88-11808*# Sundstrand Corp., Rockford, Ill.
SOLAR DYNAMIC ORGANIC RANKINE CYCLE HEAT REJECTION SYSTEM SIMULATION
V. N. HAVENS, D. R. RAGALLER (Sundstrand Corp., Rockford, IL), and D. NAMKOONG (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 222-226. refs

The use of a rotary fluid management device (RFMD) and shear flow condenser for two-phase fluid management in microgravity organic Rankine cycle (ORC) applications is examined. A prototype of the proposed Space Station ORC heat rejection system was constructed to evaluate the performance of the inventory control method. The design and operation of the RFMD, shear flow condenser, and inventory control fluid accumulator are described. A schematic diagram of the ORC, RFMD, and condenser, and a functional diagram of the heat rejection system for the ORC are presented. I.F.

A88-11811*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A NOVEL PHOTOVOLTAIC POWER SYSTEM WHICH USES A LARGE AREA CONCENTRATOR MIRROR
ANNE ARRISON (NASA, Lewis Research Center, Cleveland, OH) and NAVID FATEMI (Cleveland State University, OH) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 241-247. refs

A preliminary analysis has been made of a novel photovoltaic power system concept. The system is composed of a small area, dense photovoltaic array, a large area solar concentrator, and a battery system for energy storage. The feasibility of such a system is assessed for space power applications. The orbital efficiency, specific power, mass, and area of the system are calculated under various conditions and compared with those for the organic Rankine cycle solar dynamic system proposed for Space Station. Near term and advanced large area concentrator photovoltaic systems not only compare favorably to solar dynamic systems in terms of performance but offer other benefits as well. Author

A88-11812*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DEVELOPMENT OF AN ADVANCED PHOTOVOLTAIC CONCENTRATOR SYSTEM FOR SPACE APPLICATIONS
MICHAEL F. PISZCZOR, JR. (NASA, Lewis Research Center, Cleveland, OH) and MARK J. O'NEILL (ENTECH, Inc., Dallas, TX) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 248-253. Previously announced in STAR as N87-24531. refs

Recent studies indicate that significant increases in system performance (increased efficiency and reduced system mass) are possible for high power space based systems by incorporating technological developments with photovoltaic power systems. The Advanced Photovoltaic Concentrator Program is an effort to take advantage of recent advancements in refractive optical elements. By using a domed Fresnel lens concentrator and a prismatic cell cover, to eliminate metallization losses, dramatic reductions in the required area and mass over current space photovoltaic systems are possible. The advanced concentrator concept also has significant advantages when compared to solar dynamic Organic Rankine Cycle power systems in Low Earth Orbit applications where energy storage is required. The program is currently involved in the selection of a material for the optical element that will survive the space environment and a demonstration of the system performance of the panel design. Author

A88-11813*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
PERFORMANCE CHARACTERISTICS OF A COMBINATION SOLAR PHOTOVOLTAIC HEAT ENGINE ENERGY CONVERTER
DONALD L. CHUBB (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 254-263. Previously announced in STAR as N87-23028. refs

A combination solar photovoltaic heat engine converter is proposed. Such a system is suitable for either terrestrial or space power applications. The combination system has a higher efficiency than either the photovoltaic array or the heat engine alone can attain. Advantages in concentrator and radiator area and receiver mass of the photovoltaic heat engine system over a heat-engine-only system are estimated. A mass and area comparison between the proposed space station organic Rankine power system and a combination PV-heat engine system is made. The critical problem for the proposed converter is the necessity for high temperature photovoltaic array operation. Estimates of the required photovoltaic temperature are presented. Author

A88-11815*# Texas A&M Univ., College Station.
RELIABILITY MODELS FOR SPACE STATION POWER SYSTEM
C. SINGH, A. D. PATTON, Y. KIM (Texas A & M University, College Station), and H. WAGNER (NASA, Johnson Space Center, Houston, TX) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 268-273.

This paper presents a methodology for the reliability evaluation of Space Station power system. The two options considered are the photovoltaic system and the solar dynamic system. Reliability models for both of these options are described along with the methodology for calculating the reliability indices. Author

A88-11816*# National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.
PRELIMINARY CONCEPTUAL DESIGN AND WEIGHT OF A ONE-MEGAWATT SPACE-BASED LASER POWER STATION UTILIZING A SOLAR-PUMPED IODINE LASANT
R. J. DE YOUNG, G. H. WALKER, M. D. WILLIAMS, G. L. SCHUSTER, and E. J. CONWAY (NASA, Langley Research Center, Hampton, VA) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 274-280. refs

A preliminary conceptual design of a space-based solar-pumped iodide laser emitting 1 MW of laser power for space-to-space power transmission is described. A near-parabolic solar collector focuses sunlight onto the i-C4F9I lasant within a transverse-flow optical cavity. Using waste heat, a thermal system supplies compressor and auxiliary power. The major system components are designed with weight estimates assigned. In particular, it is found that laser efficiency is not a dominant weight factor, the dominant factor being the laser transmission optics. The station mass is 92,000 kg, requiring approximately eight Shuttle flights to LEO, where an orbital transfer vehicle can transport it to the final altitude of 6378 km. Author

A88-11817#
ELECTRICAL POWER SYSTEM FOR LOW EARTH ORBIT SPACECRAFT APPLICATIONS
P. R. K. CHETTY (Fairchild Space Co., Germantown, MD) IN:

IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 281-287.
(Contract N00014-86-C-2004)

The results of a tradeoff study to select an electrical power system configuration that is best suited for low-earth-orbit (LEO) spacecraft with various output power capabilities are presented. Two EPS configurations used for LEO spacecraft, i.e., (1) one using a direct energy transfer (DET) approach and (2) one using a peak power transfer (PPT) approach are described in detail and compared. At spacecraft power requirement of 800 watts or less, it is highly advantageous to choose the PPT approach to design an electrical power system for low earth orbit spacecraft. However, for a spacecraft in higher orbit and/or with higher power requirements, the DET-based power system is the optimum choice. Author

A88-11822#
DESIGN TECHNIQUES FOR 20K HZ POWER CONVERTERS
J. A. MARTIN and W. DUDLEY (Martin Marietta Corp., Denver, CO) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 309-312.

The selection of a 20K Hz power system for Space Station has generated a need for 20K Hz to dc and low frequency ac load converters. These converters are necessary to supply power to the previously designed 28V dc loads, 400 Hz motor loads, and other low voltage dc loads common in spacecraft applications. Straight forward converter techniques such as simple transformer-rectified-filters and line comutating schemes produce untolerable EMC for spacecraft use if not properly designed. This paper will discuss some basic design techniques for building 20K Hz load converters. One of the most critical stages of the 20K Hz load converters are the input filters. Discussions of the various input filter topologies include the breadboard and analytical results. Author

A88-11826*# Texas A&M Univ., College Station.
INCIPIENT FAULT DETECTION AND POWER SYSTEM PROTECTION FOR SPACEBORNE SYSTEMS
B. DON RUSSELL (Texas A & M University, College Station) and IRENE M. HACKLER (NASA, Johnson Space Center, Houston, TX) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 331-337. refs

A program was initiated to study the feasibility of using advanced terrestrial power system protection techniques for spacecraft power systems. It was designed to enhance and automate spacecraft power distribution systems in the areas of safety, reliability and maintenance. The proposed power management/distribution system is described as well as security assessment and control, incipient and low current fault detection, and the proposed spaceborne protection system. It is noted that the intelligent remote power controller permits the implementation of digital relaying algorithms with both adaptive and programmable characteristics. K.K.

A88-11827*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
COMPUTER MODELING AND SIMULATION OF A 20KHZ AC DISTRIBUTION SYSTEM FOR SPACE STATION
FU-SHENG TSAI and FRED C. LEE (Virginia Polytechnic Institute and State University, Blacksburg) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 338-344. refs
(Contract NAG3-551)

A computer model of a 20 kHz, ac distribution testbed for Space Station is presented. The system consists of six resonant inverters, a one-hundred-meter transmission line, and three load receivers: a dc receiver, a bidirectional receiver, and an ac receiver. A model library is generated characterizing all system components. The system's local and global behaviors are investigated using the EASY5 dynamic analysis program. Author

A88-11828#
ALLOCATING ENERGY TO EXPERIMENTS ON THE SPACE STATION
THEODORE J. SHESKIN (Cleveland State University, OH) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 345-349.

Research was performed at NASA Lewis to allocate energy to laboratory experiments on the Space Station in a power starved environment. The problem was formulated as a zero/one integer linear program with the objective of maximizing the sum of the priorities of the candidate experiments. Numerical results were obtained for an example problem involving two experiments competing for 59 KWH of energy over a 90 minute planning horizon. The energy allocation problem was solved on an IBM PC using the LINDO/PC code for zero/one variables. K.K.

A88-11830*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EMC AND POWER QUALITY STANDARDS FOR 20-KHZ POWER DISTRIBUTION
IRVING G. HANSEN (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 356-359. Previously announced in STAR as N87-22004.

The Space Station Power Distribution System has been baselined as a sinusoidal single phase, 440 VRMS system. This system has certain unique characteristics directly affecting its application. In particular, existing systematic description and control documents were modified to reflect the high operating frequency. This paper will discuss amendments made on Mil STD 704 (Electrical Power Characteristics), and Mil STD 461-B (Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference). In some cases these amendments reflect changes of several orders of magnitude. Implications and impacts of these changes are discussed. Author

A88-11831#
COMPARATIVE STUDY OF CABLE CONSTRUCTION FOR 20 KHZ POWER DISTRIBUTION
WILLIAM W. PUTNEY, SCOTT J. MCKAY, and KENNETH A. FREEMAN (Martin Marietta Corp., Denver, CO) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 360-365.

Problems associated with transmission of 20 kHz power because of skin effect are well known. At 20 kHz, classical cable constructions (i.e., solid circular and those based on circular layup of multiple noninsulated strands) larger than 18 gauge utilize only a portion of the conductor cross section to carry current. The unused metal internal to the conduction layer ('skin') can represent considerable excess weight, volume, and material cost for relatively large diameters. In this paper several special constructions have been studied to facilitate making the best choice for given current levels and cable lengths to minimize or eliminate the wasted copper. Among the candidate constructions were Litz, flat conductor, coaxial, and multiple twisted pair. Selection criteria were efficiency of copper utilization, flexibility, EMI, impedances, volume, weight, manufacturing and assembly costs, and whether existing, new, or modified existing termination techniques and hardware would be used. Author

A88-11853*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN INTEGRATED APPROACH TO SPACE STATION POWER SYSTEM AUTONOMOUS CONTROL
JAMES L. DOLCE (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 499-508. refs

Space Station electrical power management must be accomplished autonomously in order to decrease both airborne and ground support costs. Attention is presently given to the augmentation of terrestrial utility algorithmic decision aids for power dispatching for space station use, using expert systems to direct power demand analyses and the integration of results into operational decisions. Functions to be thus managed encompass power scheduling, energy allocation, failure cause diagnoses, goal proposal and plan preparation, consequence evaluation, and execution plan selection. The operating states of the system are normal, preventive, emergency, and restorative. O.C.

A88-11854#
APPLICATIONS FOR POWER CONTROL WITHIN A SPACE STATION MODULE
RICK WALSH (Martin Marietta Corp., Denver, CO) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 509-513.

Research is currently underway under contract with NASA/MSFC to research technologies for the automation of load power distribution and management within Space Station modules. A key technology here is artificial intelligence (AI). The numerous aspects of automating power control to reduce ground intervention have been examined to identify those AI would most benefit. This has resulted in multiple independent expert systems for load scheduling, load shed prioritizing (for rapid system safing), and fault management. These systems interface directly to the operational power management environment, provide substantial operations information and allow a wide range of user interaction. Here the major functional decomposition of power control activities and the analysis of AI applicability that led to these expert systems are discussed. Author

A88-11856#
USE OF A DISTRIBUTED MICROPROCESSOR NETWORK FOR CONTROL OF THE SPACE STATION ELECTRICAL POWER SYSTEM
EDWARD W. GHOLDSTON and JOSEPH R. CECKA (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 522-527. refs

A hierarchically structured distributed computer system is proposed for the NASA Space Station's Electrical Power System in which local processors furnish high speed local control, data processing, and data compression, while the higher-level central processors (which have access to global information) provide system-wide control. All processors are written in ADA. The purposes of autonomous control are: (1) the minimization of crew and ground support requirements, (2) the improvement of system efficiency, and (3) the reduction of operating costs. Both photovoltaic and solar dynamic electrical energy systems will be used. O.C.

A88-11857#
A CONCEPT FOR STANDARD LOAD CENTER AUTOMATION
KENNETH A. FREEMAN and CARL O. PISTOLE (Martin Marietta Corp., Denver, CO) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 528-532.

In this paper, the requirements for hardware needed to support automation are examined. The generic functions performed in a spacecraft power system are defined, and they are examined in the context of the Space Station control architecture. Functions performed in local power distribution are developed in this context, and requirements for automation hardware needed to implement the control architecture are then examined. The primary focus of this paper is the local power distribution and control unit known as a load center. Author

A88-11860#
AUTOMATED SPACE POWER DISTRIBUTION AND LOAD MANAGEMENT
WILLIAM D. MILLER and ELLEN F. JONES (Martin Marietta Corp., Denver, CO) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 544-546.

An investigation of automation methods for load management and power distribution within a Space Station utility power system with low levels of ground station intervention and rapid system reconfiguration and fault management capabilities has given attention to parallel-distributed control divisions. This can be accomplished by a modular hardware configuration in which the system state is maintained in an asynchronous, low-level, parallel architecture. AI expert systems provide initial load configurations and command lists for each of the lowest level process controllers. O.C.

A88-11861*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LERC POWER SYSTEM AUTONOMY PROGRAM 1990 DEMONSTRATION
KARL A. FAYMON, GALE R. SUNDBERG, ROBERT R. BERCAW (NASA, Lewis Research Center, Cleveland, OH), and DAVID J. WEEKS (NASA, Marshall Space Flight Center, Huntsville, AL) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 547-551.

The NASA Lewis Research Center has undertaken a program for the development of space systems automation, with a view to increased reliability, safety, payload capability, and decreased operational costs. The NASA Space Station is a primary area of application for the techniques thus developed. Attention is presently given to the activities associated with the Power Systems Autonomy Demonstration Project, which has a projected demonstration date in 1990 and will integrate knowledge-based systems into a real-time environment. Two coordinated systems under expert system control will be demonstrated. O.C.

A88-11863*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
AUTOMATED LOAD MANAGEMENT FOR SPACECRAFT POWER SYSTEMS
LOUIS F. LOLLAR (NASA, Marshall Space Flight Center, Huntsville, AL) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 557-560.

An account is given of the results of a study undertaken by NASA's Marshall Space Flight Center to design and implement the load management techniques for autonomous spacecraft power systems, such as the Autonomously Managed Power System Test Facility. Attention is given to four load-management criteria, which encompass power bus balancing on multichannel power systems, energy balancing in such systems, power quality matching of loads to buses, and contingency load shedding/adding. Full implementation of these criteria calls for the addition of a second power channel. O.C.

A88-11870*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
A SYSTEMS ENGINEERING APPROACH TO AUTOMATED FAILURE CAUSE DIAGNOSIS IN SPACE POWER SYSTEMS
JAMES L. DOLCE and KARL A. FAYMON (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 590-600. refs

Automatic failure-cause diagnosis is a key element in autonomous operation of space power systems such as Space Station's. A rule-based diagnostic system has been developed for determining the cause of degraded performance. The knowledge required for such diagnosis is elicited from the system engineering process by using traditional failure analysis techniques. Symptoms, failures, causes, and detector information are represented with structured data; and diagnostic procedural knowledge is represented with rules. Detected symptoms instantiate failure modes and possible causes consistent with currently held beliefs about the likelihood of the cause. A diagnosis concludes with an explanation of the observed symptoms in terms of a chain of possible causes and subcauses. Author

A88-11881#
COOPERATING EXPERT SYSTEMS FOR POWER SYSTEMS
DONNIE R. FORD (Alabama, University, Huntsville) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 2. New York, American Institute of Aeronautics and Astronautics, 1987, p. 665-667. refs

A prototype system containing two expert systems and concerned with subsystem and payload scheduling for the Space Station is described. The first expert system is a fault diagnostic and isolation system and the second is an experiment, payload, and subsystem scheduler. The techniques employed by the Fault Isolation Expert System and the Space Station Experiment Scheduler in order to attain their scheduling objectives are discussed. The interface between the two expert systems is examined. It is determined that the prototype system is effective for scheduling Space Station subsystems and payloads. I.F.

A88-11882#
EXPERT SYSTEM FOR FAULT DETECTION AND RECOVERY FOR A SPACE BASED POWER MANAGEMENT AND DISTRIBUTION SYSTEM
BRYAN WALLS IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 2. New York, American Institute of Aeronautics and Astronautics, 1987, p. 668-671.

This paper describes Starr, an expert system for fault detection and recovery in a representative power management and distribution system such as might appear on the Space Station or other large space based applications. It is modeled on NASA Marshall Space Flight Center's autonomously managed power system (AMPS) breadboard, a system containing a 75 kW solar array simulator, a 16 kw load center, and a large nickel cadmium battery, all controlled by three embedded controllers. Original prototyping is being done on an AI workstation using the Knowledge Engineering Environment. Though based on AMPS, the design has been modular to allow easy change of the expert system for various monitored systems. Author

A88-13187
SPACECRAFT SOLAR ARRAY SUBSTRATE DEVELOPMENT
THU P. STANKUNAS, W. I. GREENWAY, and G. R. HOLMQUIST (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Advanced materials technology '87; Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr. 6-9, 1987. Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 749-759.

A materials and processes development effort was performed to support the design, fabrication, and evaluation of solar array substrate composite structures for a spacecraft application. For stiffness, weight, and other design requirements, the basic sandwich structure incorporated a high-modulus graphite fiber/epoxy laminate. A film adhesive was utilized for facesheet/core bonding and as a dielectric protective layer on the surface of the substrate structure. Process studies determined cure cycles, fabrication techniques, bonding/assembly procedures, and related processing. Test coupons were fabricated and evaluated. Author

A88-15492#
LASER SOLAR POWER SATELLITES - A CASE STUDY IN TECHNOLOGY FORECASTING
C. N. ANDERSON (Queensland, University, Brisbane, Australia) IN: National Space Engineering Symposium, 2nd, Sydney, Australia, Mar. 25-27, 1986, Preprints. Volume 1. Barton, Australia/Brookfield, VT, Institution of Engineers, Australia/Brookfield Publishing Co., 1986, 7 p. refs

A proposal of extraterrestrial electricity generation with laser power beaming to earth is examined by taking actual historical production values and costs of critical elements (namely photovoltaic array structures, CO2 close cycle lasers, ground station gas turbine/generators and space transportation to low earth orbit) together with an estimation of the physical limits of the forecast criteria. A trend extrapolation reveals that this concept will not be an economical alternative to current small scale electricity generation in remote areas using diesel generators. The technique of technological forecasting is demonstrated and indicates that relatively rational planning can be achieved based on the analytical results. In this case: to abandon laser solar power satellites. Author

A88-15664
OPTIMIZATION OF THE ENERGY SYSTEMS OF MANNED ORBITAL STATIONS - MATHEMATICAL MODELING AND SELECTION OF EFFICIENT STRUCTURES [OPTIMIZATSIIA ENERGETICHESKIKH SISTEM ORBITAL'NYKH PILOTIRUEMYKH STANTSII]
SERGEI VLADIMIROVICH TIMASHEV, MIKHAIL ANATOL'EVICH KUZ'MIN, and IURII NIKOLAEVICH CHILIN Moscow, Izdatel'stvo Mashinostroenie, 1986, 232 p. In Russian. refs

Methods are presented for the overall optimization of the energy systems of manned spacecraft on the basis of a new approach to the formulation of the functional requirements for an energy system. The methods presented here are free of inherent limitations on the power of system elements, flows, and operating modes of an energy system; they provide a way to simulate the combined operation of a redundant set of system elements with simultaneous structural and parametric optimization of the system. The discussion covers the problem of energy system optimization, with the initial data specified in a deterministic manner, the effect of the operating conditions of the orbital station on the selection of an optimal energy system, and energy system optimization under conditions of indeterminacy of the initial data. V.L.

A88-15952#
THE EVOLUTION OF SPACE POWER SYSTEMS TECHNOLOGY
R. RUDEY, J. MULLIN, and D. CHAUDOIR (Sundstrand Corp., Rockford, IL) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 6 p. refs
(IAF PAPER 87-226)

The evolution of space power systems, which is driven by higher mission power requirements and longer mission life, is reviewed with particular reference to chemical, solar, and nuclear power systems. It is emphasized that a new generation of space platforms will demand options that more effectively use the energy source at reduced size, weight, and cost; these options will be derived from performance advances plus the addition of dynamic power conversion systems. A table is presented which shows space power systems, their applications, and the power range expected to be covered by the power range conversion technology by the year 2010. V.L.

A88-15953#
COLLECTOR AND RECEIVER DESIGNS FOR HIGH TEMPERATURE BRAYTON CYCLE FOR SPACE APPLICATION
W. J. DENNER, A. FRITZSCHE, and G. HELWIG (Dornier System GmbH, Friedrichshafen, Federal Republic of Germany) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 16 p. refs
(IAF PAPER 87-228)

A West German Ministry for Research and Technology study has been conducted into the development status and comparative advantages of solar dynamic power systems for spacecraft applications. Solar reflector, receiver, and energy storage baseline configurations are discussed with a view to efficiency, mass, cost effectiveness, and ease of deployment in orbit (by either EVA or automated means). Both foldable-petal segment and hexagonal truss structure-supported collector configurations are assessed; receivers considered are of the cavity and block-receiver types. O.C.

A88-15954*# Rockwell International Corp., Canoga Park, Calif.
OPTICAL MEASUREMENTS PERTAINING TO SPACE STATION SOLAR DYNAMIC POWER SYSTEMS
S. HOLLY, T. SPRINGER (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA), and K. S. JEFFERIES (NASA, Lewis Research Center, Cleveland, OH) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 16 p.
(IAF PAPER 87-229)

The Space Station solar dynamic power system is a hybrid of solar photovoltaic and solar dynamic systems, the latter of which uses a parabolic reflector to collect solar energy. This paper describes analytical results of an off-axis solar illumination on the intensity distribution in arbitrary target planes perpendicular to the axis of a parabolic reflector. Such computational capability would make it possible to predict optical intensity distributions resulting from off-axis angles of incident radiation on such target planes. To validate the computer code, experimental optical measurements were performed on the multifaceted paraboloidal collecor at the Solar Dynamic Test Facility at Rockedyne's Santa Susana Field Laboratory. The experimental data compared reasonably well with the calculated values. I.S.

A88-15958*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
SPACE STATION ELECTRICAL POWER SYSTEM
THOMAS L. LABUS and THOMAS H. COCHRAN (NASA, Lewis Research Center, Cleveland, OH) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 12 p. Previously announced in STAR as N87-26144.
(IAF PAPER 87-234)

The purpose of this paper is to describe the design of the Space Station Electrical Power System. This includes the Photovoltaic and Solar Dynamic Power Modules as well as the Power Management and Distribution System (PMAD). In addition, two programmatic options for developing the Electrical Power System will be presented. One approach is defined as the Enhanced Configuration and represents the results of the Phase B studies conducted by the NASA Lewis Research Center over the last two years. Another option, the Phased Program, represents a more measured approach to reaching about the same capability as the Enhanced Configuration. Author

A88-15964#
PAST, PRESENT AND FUTURE ACTIVITIES IN SPACE POWER TECHNOLOGY IN THE UK
A. A. DOLLERY (Royal Aircraft Establishment, Farnborough, England) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 2 p.
(IAF PAPER 87-243)

Developments in space power technology in the UK during the last 25 years are discussed. Particular emphasis is given to the Ni-Cd battery, fold-up deployable arrays, CMS cover glass, CMX ceria doped cover glass, and the solar cell evaluation and qualification facility. The development of these technologies and their uses are described. Research is currently being conducted for the development of: (1) a new solar cell cover glass CMZ; (2) a range of nickel-hydrogen battery cells for GEO and LEO; and (3) a range of GaAs solar cells for use on both planar and concentrated types of arrays. I.F.

A88-15966*# National Aeronautics and Space Administration, Washington, D.C.
PAST, PRESENT, AND FUTURE ACTIVITIES IN SPACE POWER TECHNOLOGY IN THE UNITED STATES OF AMERICA
JUDITH H. AMBRUS (NASA, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 2 p.
(IAF PAPER 87-245)

Space power technology research in the U.S. is examined. The objectives for advanced power systems are long life, safety, flexibility, modularity, growth capability, and autonomy. Research in the areas of photovoltaic arrays, electrical energy storage, and the development of solar dynamic power systems and radio thermal generators is described. The applications of advances in power generation, energy storage, and power management and distribution to the Space Station are discussed. I.F.

A88-15969#
PLASMOID POWER STATION
M. POSPISIL and L. POSPISILOVA IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 5 p. refs
(IAF PAPER 87-250)

The paper discusses the possibility of exploiting the energy of particles of solar wind captured by the magnetosphere of the earth. Experiments which would investigate the distribution of density of particles in space and the corresponding energy distribution are recommended. Author

A88-15970*# Massachusetts Inst. of Tech., Cambridge.
PLASMA CONTACTORS FOR USE WITH ELECTRODYNAMIC TETHERS FOR POWER GENERATION
D. E. HASTINGS (MIT, Cambridge, MA) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 19 p. refs
(Contract NAG9-132)
(IAF PAPER 87-251)

Plasma contactors have been proposed as a means of making good electrical contact between biased surfaces such as found at the ends of an electrodynamic tether and the space environment. A plasma contactor is a plasma source which emits a plasma cloud which facilitates the electrical connecton. The physics of this plasma cloud is investigated for contactors used as electron collectors and it is shown that contactor clouds in space will consist of a spherical core possibly containing a shock wave. Outside of the core the cloud will expand anisotropically across the magnetic field leading to a turbulent cigar shape structure along the field. This outer region is itself divided into two regions by the ion response to the electric field. A two dimensional theory of the motion of the cloud across the magnetic field is developed. The current voltage characteristic of an Argon plasma contactor cloud is estimated for several ion currents in the range of 1-100 Amperes. It is shown that small ion current contactors are more efficient than large ion current contactors. This suggests that if a plasma contactor is used on an electrodynamic tether, then a multiple tether array will be more efficient than a single tether. Author

A88-15972#
DYNAMIC POWER GENERATION FOR SOLAR POWER SATELLITES
K. KISHIMOTO and M. YASUI (Mitsubishi Heavy Industries, Ltd., Komaki, Japan) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 5 p.
(IAF PAPER 87-253)

Dynamic solar power generation for solar power satellites is examined with emphasis on the closed Brayton gas dynamic cycle as the most flexible system. Although, based on current technology,

the overall efficiency of the closed Brayton cycle, including concentrator efficiency, does not exceed 20 percent, the system has the major advantage of a wide operating range. It also provides technology for propellant (liquid hydrogen and oxygen) production in space. V.L.

A88-15989#
POWER REQUIREMENTS FOR AN ORBITING SPACE FARM
S. M. BULL (Medaris Industries, New York) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 7 p. refs
(IAF PAPER 87-242)

The concept of an orbiting space farm for growing and harvesting edible foodstuffs in a single-launch, gravity-induced space station placed in low earth orbit adjacent to the forthcoming NASA Space Station is reviewed with emphasis on power requirements. Alternative power sources are examined, and photovoltaic and solar dynamic power sources are proposed as the principal power supplies. Savings in the electrical storage capacities needed to operate the space farm during the periods when the farm is in the approximately 30-minute eclipse of its LEO orbit are demonstrated. V.L.

A88-16308* Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
A FREE-FLYING POWER PLANT FOR A MANNED SPACE STATION
M. PALUSZEK and P. MADDEN (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: Automatic control in space 1985. Oxford and New York, Pergamon Press, 1986, p. 263-268. refs
(Contract NAS9-16023)

The 0.1 Hz fundamental structural frequency anticipated for the large solar array panels required to power manned space stations is close to the attitude control system bandwidth, and within the bandwidth of crew motion disturbances. Attention is presently given to a detachment of the solar panel system to create a free-flying powerplant for the space station, and to the control system that will maintain its attitude and position relative to the space station by means of thrusters that are supplied with space station state data by a laser/optical sensor system. Power transmission alternatives for this free-flying power system are discussed. O.C.

A88-17023
SOLAR POWER SATELLITES
RICHARD R. VONDRAK (Lockheed Space Sciences Laboratory, Palo Alto, CA) IN: The solar wind and the earth. Tokyo/Dordrecht, Terra Scientific Publishing Co./D. Reidel Publishing Co., 1987, p. 286-307. refs

The construction of a solar power system in space rather than on the surface of the earth has the advantages of higher energy yield, constant power return, and the simplicity of construction; a system in space will in the course of one year generate approximately 10 times the energy of an equivalent system on earth. This paper discusses the major design features and the basic elements of a 5000 MW solar power satellite system, together with the efficiency and the output power for each element of the system. Because of its extraordinary size (a mass of about 5 x 10 to the 7th kg), a new type of rocket launch vehicle would be required, which would be completely reusable and would operate at a high frequency (the construction of a single 5000 MW satellite will require about 200 flights of the heavy-lift launch vehicle to low-earth orbit). The estimated expenditures needed for the deployment of the first solar power satellite are outlined, and the environmental effects are identified. I.S.

A88-18230* Harris Corp., Melbourne, Fla.
DEVELOPMENT OF COMPOSITE FACETS FOR THE SURFACE OF A SPACE-BASED SOLAR DYNAMIC CONCENTRATOR
SCHUYLER R. AYERS, DONALD E. MOREL, and JAMES A. SANBORN (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: Advanced composites: The latest developments; Proceedings of the Second Conference, Dearborn, MI, Nov. 16-20, 1986. Metals Park, OH, ASM International, 1986, p. 55-60.
(Contract NAS3-24670)

An account is given of the composite fabrication techniques envisioned for the production of mirror-quality substrates furnishing the specular reflectance required for the NASA Space Station's solar dynamic concentrator energy system. The candidate materials were graphite fiber-reinforced glass, aluminum, and polymer matrices whose surfaces would be coated with thin metal layers and with atomic oxygen degradation-inhibiting protective coatings to obtain the desired mirror surface. Graphite-epoxy mirror substrate samples have been found to perform satisfactorily for the required concentrator lifetime. O.C.

A88-18523* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OXIDATION-RESISTANT REFLECTIVE SURFACES FOR SOLAR DYNAMIC POWER GENERATION IN NEAR EARTH ORBIT
DANIEL A. GULINO (NASA, Lewis Research Center, Cleveland, OH), ROBERT A. EGGER (Cleveland State University, OH), and WILLIAM F. BANHOLZER (General Electric Co., Schenectady, NY) Journal of Vacuum Science and Technology A (ISSN 0734-2101), vol. 5, July-Aug. 1987, p. 2737-2741. Previously announced in STAR as N87-10960. refs

Reflective surfaces for Space Station power generation systems are required to withstand the atomic oxygen-dominated environment of near earth orbit. Thin films of platinum and rhodium, which are corrosion resistant reflective metals, have been deposited by ion beam sputter deposition onto various substrate materials. Solar reflectances were then measured as a function of time of exposure to a RF-generated air plasma. Author

A88-19002
SOLAR POWER SATELLITES - STILL IN THE DARK
MILES WEISS Space World (ISSN 0038-6332), vol. X-11-287, Nov. 1987, p. 21-25.

The technological potential and problems of solar power satellites (SPS) are reviewed. The benefits of solar power brought to one African village by NASA and AID are described. The history of the SPS project in the United States is recounted, giving the reasons for the eventual renunciation of the project. The possibility of using lunar materials for the SPS is addressed. The prospects for a Soviet SPS are considered. C.D.

A88-21601
PHOTOVOLTAICS FOR COMMERCIAL SOLAR POWER APPLICATIONS; PROCEEDINGS OF THE MEETING, CAMBRIDGE, MA, SEPT. 18, 19, 1986
DAVID ADLER, ED. (MIT, Cambridge, MA) Meeting sponsored by SPIE. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 706), 1986, 115 p. For individual items see A88-21602 to A88-21608.
(SPIE-706)

Papers are presented on efficient multijunction monolithic cascade solar cells, high efficiency silicon solar cells, point contact silicon cells, and space solar cell research. Also considered are photovoltaic power plants, the reliability of photovoltaic modules, the continuous fabrication of amorphous silicon solar cells on polymer substrates, and the density of states of amorphous silicon. Other topics include breaking the efficiency-stability-production barrier in amorphous photovoltaics, the development of flexible a-SiC/a-Si heterojunction solar cells and stable a-SiC/a-Si tandem cells with blocking barriers, and performance aspects for thin-film-silicon-hydrogen solar cells. R.R.

A88-21605* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACE SOLAR CELL RESEARCH - PROBLEMS AND POTENTIAL
DENNIS J. FLOOD (NASA, Lewis Research Center, Cleveland, OH) IN: Photovoltaics for commercial solar power applications; Proceedings of the Meeting, Cambridge, MA, Sept. 18, 19, 1986.

Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 34-39. Previously announced in STAR as N86-31793. refs

The value of a passive, maintenance-free, renewable energy source was immediately recognized in the early days of the space program, and the silicon solar cell, despite its infancy, was quickly pressed into service. Efficiencies of those early space solar arrays were low, and lifetimes shorter than hoped for, but within a decade significant advances had been made in both areas. Better performance was achieved because of a variety of factors, ranging from improvements in silicon single crystal material, to better device designs, to a better understanding of the factors that affect the performance of a solar cell in space. Chief among the latter, particularly for the mid-to-high altitude (HEO) and geosynchronous (GEO) orbits, are the effects of the naturally occurring particulate radiation environment. Although not as broadly important to the photovoltaic community at large as increased efficiency, the topic of radiation damage is critically important to use of solar cells in space, and is a major component of the NASA research program in space photovoltaics. This paper will give a brief overview of some of the opportunities and challenges for space photovoltaic applications, and will discuss some of the current research directed at achieving high efficiency and controlling the effects of radiation damage in space solar cells. Author

A88-21633
COOPERATING EXPERT SYSTEMS FOR SPACE STATION POWER DISTRIBUTION MANAGEMENT

T. A. NGUYEN and W. C. CHIOU, SR. (Lockheed Artificial Intelligence Center, Palo Alto, CA) IN: Space Station automation II, Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 7-10. refs

A software program called CARTS (cooperating ART-based systems) is described which addresses the problem of communications between expert systems aboard the International Space Station. The CARTS architecture and implementation are described. An Automated Power Management System for the Space Station is also discussed. C.D.

A88-21641
AUTONOMOUS MANAGEMENT OF THE SPACE STATION ELECTRIC ENERGY SYSTEM

JOHN MCCLURE, DOUGLAS BERMAN, and FRED SCHWEPPE (Charles Stark Draper Laboratory, Inc., MIT, Cambridge, MA) IN: Space Station automation II, Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 90-97. refs

This paper discusses some of the implementation issues associated with autonomous management of the Space Station electric energy system. An executive-based structure is proposed for handling the scheduling and real time control of the energy system. The elements of the energy system and management system are described, and each of the four blocks of the operational software is examined: the scheduler, the real-time controller, the user interface, and the executive. The input, output, and function of each block are described. Some specific aspects of the implementation of a proposed simulated annealing algorithm for solving the scheduling problem are detailed, and the results of test problems are reported. C.D.

A88-22348*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SOLAR DYNAMIC HEAT RECEIVER THERMAL CHARACTERISTICS IN LOW EARTH ORBIT

Y. C. WU, E. J. ROSCHKE, and G. C. BIRUR (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. NASA-sponsored research. refs
(AIAA PAPER 88-0472)

A simplified system model is under development for evaluating the thermal characteristics and thermal performance of a solar dynamic spacecraft energy system's heat receiver. Results based on baseline orbit, power system configuration, and operational conditions, are generated for three basic receiver concepts and three concentrator surface slope errors. Receiver thermal characteristics and thermal behavior in LEO conditions are presented. The configuration in which heat is directly transferred to the working fluid is noted to generate the best system and thermal characteristics, as well as the lowest performance degradation with increasing slope error. O.C.

A88-22676
SPACE NUCLEAR POWER SYSTEMS 1986; PROCEEDINGS OF THE THIRD SYMPOSIUM, ALBUQUERQUE, NM, JAN. 13-16, 1986

MOHAMED S. EL-GENK, ED. (New Mexico, University, Albuquerque) and MARK D. HOOVER, ED. (Lovelace Inhalation Toxicology Research Institute, Albuquerque, NM) Symposium organized by the University of New Mexico; Sponsored by ANS, Los Alamos National Laboratory, USAF, et al. Malabar, FL, Orbit Book Co., Inc. (Space Nuclear Power Systems, Volume 5), 1987, 499 p. For individual items see A88-22677 to A88-22716.

The papers presented in this volume provide an overview of recent advances in the development of safe and reliable nuclear power systems for use in the exploration and utilization of space. Topics discussed include missions and applications, nuclear safety, reactors and shielding, thermal management, and energy conversion. Other topics include systems integration, refractory alloys, radiation effects, testing, nuclear electric and nuclear propulsion, multimegawatt systems, and radioisotope generators. V.L.

A88-22677
SPACE POWER NEEDS AND FORECASTED TECHNOLOGIES FOR THE 1990S AND BEYOND

DAVID BUDEN and THOMAS ALBERT (Science Applications International Corp., Albuquerque, NM) IN: Space nuclear power systems 1986; Proceedings of the Third Symposium, Albuquerque, NM, Jan. 13-16, 1986. Malabar, FL, Orbit Book Co., Inc., 1987, p. 15-24. Research sponsored by the Science Applications International Corp. refs

A new generation of reactors for electric power will be available for space missions to satisfy military and civilian needs in the 1990s and beyond. To ensure a useful product, nuclear power plant development must be cognizant of other space power technologies. Major advances in solar and chemical technologies need to be considered in establishing the goals of future nuclear power plants. In addition, the mission needs are evolving into new regimes. Civilian and military power needs are forecasted to exceed anything used in space to date. Technology trend forecasts have been mapped as a function of time for solar, nuclear, chemical, and storage systems to illustrate areas where each technology provides minimum mass. Other system characteristics may dominate the usefulness of a technology on a given mission. This paper will discuss some of these factors, as well as forecast future military and civilian power needs and the status of technologies for the 1990s and 2000s. Author

A88-22691
MONOLITHIC FUEL CELL BASED POWER SOURCE FOR BURST POWER GENERATION

D. C. FEE, S. K. BHATTACHARYYA, D. E. BUSCH, L. W. CARLSON, T. D. CLAAR (Argonne National Laboratory, IL) et al. IN: Space nuclear power systems 1986; Proceedings of the Third Symposium, Albuquerque, NM, Jan. 13-16, 1986. Malabar, FL, Orbit Book Co., Inc., 1987, p. 209-214. SDIO-DARPA-supported research. refs
(Contract W-31-109-ENG-38)

A unique fuel cell coupled with a low power nuclear reactor presents an attractive approach for Strategic Defense Initative (SDI) burst power requirements. The high power, long duration bursts, quoted in the open literature, (100 MWe, 200 s) appear achievable within a single shuttle launch limitation with appropriate development of the concept. Author

A88-26150
SOLAR-THERMODYNAMIC POWER SYSTEMS IN SPACE [SOLARNO-TERMODYNAMICZNE UKLADY ZASILANIA W KOSMOSIE]
MARIAN KLEIN (Polskie Towarzystwo Astronautyczne, Katowice, Poland) Postepy Astronautyki (ISSN 0373-5982), vol. 20, no. 1-2, 1987, p. 145-158. In Polish. refs

The physical characteristics of a dynamic solar system with the organic Rankine cycle are presented. It is shown that dynamic power generation can satisfy the high energy requirements of future space applications. A theoretical diagram and physical equations for efficiency are presented as well as a functional scheme of the device. Toluene is shown to be the optimal working fluid. K.K.

A88-27886#
NUMERICAL ANALYSIS OF INTERACTION OF A HIGH-VOLTAGE SOLAR ARRAY WITH IONOSPHERIC PLASMA
KYOICHI KURIKI (Tokyo, University, Japan) and HITOSHI KUNINAKA Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, Nov.-Dec. 1987, p. 512-517. refs

Three-dimensional analysis of the solar array that exposes the surfaces at a relatively high potential and flies in the ionospheric plasma was conducted. For the standard ionospheric conditions, the drain power was calculated at about 0.3 percent of the solar generated power, which is rather insignificant. On the other hand, the ion forces were found to be enhanced by the large electric potential difference between the solar array and the plasma and must affect significantly the motion of spacecraft with the neutral particle drag. Author

A88-28250
OPTIMIZATION OF THE PARAMETERS OF A SOLAR PHOTOELECTRIC SYSTEM EXPOSED TO COSMIC RAYS [OPTIMIZATSIIA PARAMETROV SOLNECHNOI FOTOELEKTRICHESKOI USTANOVKI, PODVERZHENNOI VOZDEISTVIIU KOSMICHESKOI RADIATSII]
O. F. ZAITSEV Geliotekhnika (ISSN 0130-0997), no. 6, 1987, p. 23-29. In Russian. refs

A model and an algorithm are developed for the optimization of the performance characteristics of concentration-type solar photoelectric systems consisting of planar solar arrays, concentrator reflecting films, and supporting structures. The model and the algorithm make it possible to accurately predict the parameters of concentration-type photoelectric systems at the design stage. It is shown that, under conditions of considerable radiation-induced damage, the performance of such systems can be improved by using low-potential concentration systems and discrete reservation of output power. V.L.

A88-30317#
FLUID LOSS FROM A PUNCTURE OF A SPACE RADIATOR
D. E. TILTON and L. C. CHOW (Kentucky, University, Lexington) Journal of Thermophysics and Heat Transfer (ISSN 0887-8722), vol. 2, Jan. 1988, p. 84-86. Previously cited in issue 19, p. 2615, Accession no. A86-39925. refs
(Contract F49620-82-C-0035)

A88-31396*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STRUCTURAL ASSESSMENT OF A SPACE STATION SOLAR DYNAMIC HEAT RECEIVER THERMAL ENERGY STORAGE CANISTER
M. T. TONG (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH), T. W. KERSLAKE, and R. L. THOMPSON (NASA, Lewis Research Center, Cleveland, OH) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 162-172. refs (AIAA PAPER 88-2487)

This paper assesses the structural performance of a Space Station thermal energy storage (TES) canister subject to orbital solar flux variation and engine cold start-up operating conditions. The impact of working fluid temperature and salt-void distribution on the canister structure are assessed. Both analytical and experimental studies were conducted to determine the temperature distribution of the canister. Subsequent finite-element structural analyses of the canister were performed using both analytically and experimentally obtained temperatures. The Arrhenius creep law was incorporated into the procedure, using secondary creep data for the canister material, Haynes-188 alloy. The predicted cyclic creep strain accumulations at the hot spot were used to assess the structural performance of the canister. In addition, the structural performance of the canister based on the analytically-determined temperature was compared with that based on the experimentally-measured temperature data. Author

N88-11730 European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
ENVIRONMENTAL INTERACTIONS OF SOLAR GENERATORS IN SPACE
K. BOGUS *In* CNES, Spacecraft Environment Technology p 663-679 Apr. 1987
Avail: CEPADUES-Editions, Toulouse, France

The effects on deployable solar generators of Sun/eclipse thermal cycles, low Earth orbit plasma, atomic oxygen, ultraviolet radiation and particles, the residual atmosphere, micrometeorites, and magnetic substrorms are reviewed. Space environment simulation test results are discussed. ESA

N88-11745*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PHOTOVOLTAIC POWER MODULES FOR NASA'S MANNED SPACE STATION
CHARLES A. TATRO 1987 13 p Proposed for presentation at the 1988 Solar Energy Conference, Golden, Colo., 10-14 Apr. 1988, sponsored by ASME
(NASA-TM-100229; E-3850; NAS 1.15:100229) Avail: NTIS HC A03/MF A01 CSCL 10C

The capability and the safety of manned spacecraft are largely dependent upon reliable electric power systems. Two similar space power systems able to survive the low Earth orbit environment, are being considered for NASA's Manned Space Station (SS), scheduled to begin operation in the mid 1990's. The Space Station Electric Power System (EPS) is composed of Photovoltaic (PV) Power Modules, Solar Dynamic (SD) Power Modules, and the Power Management and Distribution (PMAD) System. One EPS configuration will deliver 37.5 kW of PV based, utility grade, ac power to SS users. A second 75 kWe PV based EPS option is also being considered for SS deployment. The two EPS options utilize common modules and differ only in the total number of PV Power Modules used. Each PV Power Module supplies 18.75 kWe of ac power and incorporates its own energy storage and thermal control. The general requirements and the current preliminary design configuration of the Space Station PV Power Modules are examined. Author

N88-11948*# General Dynamics Corp., San Diego, Calif. Space Systems Div.
THE AC POWER SYSTEM TESTBED Final Report
J. MILDICE and R. SUNDBERG Nov. 1987 138 p
(Contract NAS3-24399)
(NASA-CR-179068; NAS 1.26:179068) Avail: NTIS HC A07/MF A01 CSCL 09C

The object of this program was to design, build, test, and deliver a high frequency (20 kHz) Power System Testbed which would electrically approximate a single, separable power channel of an IOC Space Station. That program is described, including the technical background, and the results are discussed showing that the major assumptions about the characteristics of this class of hardware (size, mass, efficiency, control, etc.) were substantially correct. This testbed equipment was completed and delivered and is being operated as part of the Space Station Power System Test Facility. Author

N88-13429*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LOW EARTH ORBIT ENVIRONMENTAL EFFECTS ON THE SPACE STATION PHOTOVOLTAIC POWER GENERATION SYSTEMS
HENRY K. NAHRA 1987 20 p Proposed for presentation at the 1988 Solar Energy Conference, Golden, Colo., 10-14 Apr. 1988; sponsored by ASME
(NASA-TM-100230; E-3852; NAS 1.15:100230) Avail: NTIS HC A03/MF A01 CSCL 10A

A summary of the Low Earth Orbital Environment, its impact on the Photovoltaic Power systems of the space station and the solutions implemented to resolve the environmental concerns or issues are described. Low Earth Orbital Environment (LEO) presents several concerns to the Photovoltaic power systems of the space station. These concerns include atomic oxygen interaction with the polymeric substrate of the solar arrays, ionized environment effects on the array operating voltage, the effects of the meteoroids and debris impacts and penetration through the different layers of the solar cells and their circuits, and the high energy particle and radiation effects on the overall solar array performance. Potential solutions to some of the degrading environmental interactions that will provide the photovoltaic power system of the space station with the desired life are also summarized. Author

N88-13814# Centre National d'Etudes Spatiales, Toulouse (France).
THE HIGH PERFORMANCE SOLAR ARRAY GSR3
A. MAMODE, J. BARTEVIAN, J. L. BASTARD, P. AUFFRAY, and A. PLAGNE (Societe Nationale Industrielle Aerospatiale, Les Mureaux, France.) Paris, France SNIAS 1987 10 p Previously announced as N87-28972
(SNIAS-872-422-106; ETN-88-91209) Avail: NTIS HC A02/MF A01

A foldout solar array for communication satellites was developed. A wing composed of 4 panels of 1.6 x 1.5 m and a Y-shaped yoke, and a wing with 3 panels of 2.4 x 2.4 m were made. End of life performance goal is greater than 35 W/kg with BSR 180 micron solar cells, and 50 W/kg using 50 micron BSFR cells. Analysis shows that all identified requirements can be covered with current skin made of open weave very high modulus carbon fiber, reinforcements of unidirectional carbon fiber, honeycomb in current section, hold-down inserts made of wound carbon fibers, titanium hinge fitting, and Kapton foil (25 or 50 micron thickness). Tests confirm performance predictions. ESA

N88-14869*# Texas A&M Univ., Galveston. Dept. of Marine Science.
POWER AND CHARGE DISSIPATION FROM AN ELECTRODYNAMIC TETHER Final Report
GERALD E. HITE In NASA, Lyndon B. Johnson Space Center, Houston, Tex. NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 1 20 p Nov. 1987
Avail: NTIS HC A15/MF A01 CSCL 09C

The Plasma Motor-Generator project utilizes the influence of the geomagnetic field on a conductive tether attached to a LEO spacecraft to provide a reversible conversion of orbital energy into electrical energy. The behavior of the current into the ionospheric plasma under the influence of the geomagnetic field is of significant experimental and theoretical interest. Theoretical calculations are reviewed which start from Maxwell's equations and treat the ionospheric plasma as a linear dielectric medium. These calculations show a charge emitting tether moving in a magnetic field will generate electromagnetic waves in the plasma which carry the charge in the direction of the magnetic field. The ratio of the tether's speed to the ion cyclotron frequency which is about 25 m for a LEO is a characteristic length for the phenomena. Whereas for the dimensions of the contact plasma much larger than this value the waves are the conventional Alfven waves, when the dimensions are comperable or smaller, diffraction effects occur similar to those associated with Fresnel diffraction in optics. The power required to excite these waves for a given tether current is used to estimate the impedance associated with this mode of charge dissipation. Author

N88-15838*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STATUS OF 20 KHZ SPACE STATION POWER DISTRIBUTION TECHNOLOGY
IRVING G. HANSEN Jan. 1988 12 p Presented at the Applied Power Electronics Conference and Exposition (APEC 88), New Orleans, La., 1-5 Feb. 1988; sponsored by IEEE
(NASA-TM-100781; E-3951; NAS 1.15:100781) Avail: NTIS HC A03/MF A01 CSCL 10B

Power Distribution on the NASA Space Station will be accomplished by a 20 kHz sinusoidal, 440 VRMS, single phase system. In order to minimize both system complexity and the total power coversion steps required, high frequency power will be distributed end-to-end in the system. To support the final design of flight power system hardware, advanced development and demonstrations have been made on key system technologies and components. The current status of this program is discussed. Author

N88-16185# Technische Univ., Berlin (West Germany). Inst. of Aerospace.
DEFINITION AND ECONOMIC EVALUATION OF SPACE SOLAR POWER SYSTEMS (SSPS), PART 1
H. H. KOELLE, K. SPUTEK, and M. SCHULZE 15 Aug. 1987 37 p
(ILR-MITT-184-1(1987); ETN-88-91444) Avail: NTIS HC A03/MF A01

A life cycle model of a typical space power system (SPS) in the first half of the next century is described. Inputs for this logistics model are: life cycle duration (100 yr); power level of the SPS at the end of life cycle assumed (500 GW); power level for single SPS unit (5 GW); availability of space power units (90 %); and specific mass (Mg/MW) of SPS as a function of time. A system of 100 operating space power units in geostationary orbit with an output of 500 GW in its 50th year requires in this year a total mass flow of 200,000 T. To operate the system, a crew size in GEO is 600 people. The total mass installed in the SPS is 6 million metric tons. To transport this material to the GEO from Earth and from the Moon, average annual launch rates of 300 for the lunar bus and 340 for the heavy lift launch vehicle during the 50 yr time period are required. The average annual output of the SPS is economically attractive: 2188 TWh at 7.4 mills/kWh. ESA

N88-16190# Technische Univ., Berlin (West Germany). Inst. of Aerospace.
DEFINITION AND ECONOMIC EVALUATION OF SPACE SOLAR POWER SYSTEMS (SSPS), PART 2
H. H. KOELLE, K. SPUTEK, and M. SCHULZE 15 Aug. 1987 79 p
(ILR-MITT-184-2(1987); ETN-88-91445) Avail: NTIS HC A05/MF A01

A life cycle model of a typical space power system (SPS) in the first half of the next century is described. Inputs for this logistics model are: life cycle duration (100 yr); power level of the SPS at the end of life cycle assumed (500 GW); power level for single SPS unit (5 GW); availability of space power units (90 %); and specific mass (Mg/MW) of SPS as a function of time. The simulation model comprises 171 equations describing the interrelationships between the system variables and parameters. The computer code developed for this simulation model is available upon request. The printouts of all system variables calculated as functions of time are presented. ESA

N88-16547*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
PLASMA CONTACTORS FOR USE WITH ELECTODYNAMIC TETHERS FOR POWER GENERATION Final Report
D. E. HASTINGS and N. A. GATSONIS 21 Jan. 1988 29 p

(Contract NAG9-132)
(NASA-CR-182424; NAS 1.26:182424) Avail: NTIS HC A03/MF A01 CSCL 20I

Plasma contactors are proposed as a means of making good electrical contact between biased surfaces such as found at the ends of an electrodynamic tether and the space environment. The plasma contactor emits a plasma cloud which facilitates the electrical connection. The physics of this plasma cloud is investigated for contactors used as electron collectors. The central question addressed is whether the electrons collected by a plasma contactor come from the far field or by ionization of local neutral gas. This question is important because the system implications are different for the two mechanisms. It is shown that contactor clouds in space will consist of a spherical core possibly containing a shock wave. Outside of the core the cloud will expand anisotropically across the magnetic field leading to a turbulent cigar shape structure along the field. This outer region is itself divided into two regions by the ion response to the electric field. A two-dimensional theory for the outer regions of the cloud is developed. The current voltage characteristic of an Argon plasma contactor cloud is estimated for several ion currents in the range of 1 to 100 Amperes. It is suggested that the major source of collected electrons comes by ionization of neutral gas while collection of electrons from the far field is relatively small.
Author

N88-16773# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands)
SATELLITE POWER SYSTEMS UNDER CONSIDERATION BY THE UNITED NATIONS
D. KASSING *In its* ESA Bulletin No. 25 p 53-59 Feb. 1981
Avail: NTIS HC A05/MF A01

It is argued that satellite power systems (SPS) could generate electrical energy on a large scale. There are, however, a number of technical, environmental, and socioeconomic uncertainties that require further study before any decision regarding SPS implementation can be envisaged in the late 1980s or early 1990s. Issues associated with SPS that require international cooperation are addressed.
Author (ESA)

N88-17106# British Aerospace Dynamics Group, Bristol (England). Space and Communications Div.
STUDY OF LARGE SOLAR ARRAYS (SOLA), PHASE 2A Final Report
J. POPE, comp.; C. P. LEE, R. K. BRADFORD, E. WINTER, H. BEBERMEIER, G. BEHRENS, W. SCHMITT, and H. AKISTER (Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost.) Paris, France ESA Jul. 1983 54 p
(Contract ESA-4903/81-NL-JS(SC))
(BAE-SS/1109; ESA-CR(P)-1819-VOL-1; ETN-87-90511) Avail: NTIS HC A04/MF A01

It is shown that it is feasible to manufacture a basic module from which arrays of various sizes can be constructed within acceptable limits defined by power losses and power to weight criteria in the range from 15 to 30 kW, in steps of 2 kW, with a choice of low (52 V) or high (156 V) operating voltage levels. This modular design can be extended to provide array system powers up to 60 kW, although above 30 kW, only the high voltage operating level is practical, due to the high resistive power losses associated with the length of array, hence harness, required for such operating power levels. Operating levels are 30 W/kg at 15 kW and 42 W/kg at 30 kW. These levels could be increased by optimizing the design for specific operating power levels, but at the expense of modularity. It is unlikely that the 50 W/kg goal can be reached.
Author (ESA)

N88-17480# British Aerospace Dynamics Group, Bristol (England). Space and Communications Div.
STUDY OF LARGE SOLAR ARRAYS (SOLA). PHASE 2A: AMPLIFYING INFORMATION TO FINAL REPORT (SS/1109) Final Report
Paris, France Jul. 1983 112 p
(Contract ESA-4903/81-NL-JS(SC))
(BAE-SS/1110; ESA-CR(P)-1819-VOL-2; ETN-87-90512) Avail: NTIS HC A06/MF A01

It is shown that it is feasible to manufacture a basic module from which arrays of various sizes can be constructed within acceptable limits defined by power losses and power-to-weight criteria in the range from 150 to 30 kW, in steps of 2 kW, with a choice of low (52 V) or high (156 V) operating voltage levels. This modular design can be extended to provide array system powers up to 60 kW, although above 30 kW only the high voltage operating level is practical, due to the high resistive power losses associated with the length of array, hence harness, required for such operating power levels. Operating levels are 30 W/kg at 15 kW and 42 W/kg at 30 kW. These levels could be increased by optimizing the design for specific operating power levels, but at the expense of modularity. It is unlikely that the 50 W/kg goal can be reached.
Author (ESA)

N88-17715*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SIMULATION TEST BEDS FOR THE SPACE STATION ELECTRICAL POWER SYSTEM
GERALD G. SADLER Mar. 1988 20 p
(NASA-TM-100786; E-3958; NAS 1.15:100786) Avail: NTIS HC A03/MF A01 CSCL 22B

NASA Lewis Research Center and its prime contractor are responsible for developing the electrical power system on the space station. The power system will be controlled by a network of distributed processors. Control software will be verified, validated, and tested in hardware and software test beds. Current plans for the software test bed involve using real time and nonreal time simulations of the power system. This paper will discuss the general simulation objectives and configurations, control architecture, interfaces between simulator and controls, types of tests, and facility configurations.
Author

N88-18068*# Harris Corp., Melbourne, Fla. Government Aerospace Systems Div.
SOLAR CONCENTRATOR ADVANCED DEVELOPMENT PROGRAM, TASK 1 Final Report
Jun. 1986 223 p
(Contract NAS3-24670)
(NASA-CR-179489; NAS 1.26:179489) Avail: NTIS HC A10/MF A01 CSCL 10A

Solar dynamic power generation has been selected by NASA to provide power for the space station. Solar dynamic concentrator technology has been demonstrated for terrestrial applications but has not been developed for space applications. The object of the Solar Concentrator Advanced Development program is to develop the technology of solar concentrators which would be used on the space station. The first task of this program was to develop conceptual concentrator designs and perform trade-off studies and to develop a materials data base and perform material selection. Three unique concentrator concepts, Truss Hex, Spine Radial Panel and Domed Fresnel, were developed and evaluated against weighted trade criteria. The Truss Hex concept was recommended for the space station. Materials data base development demonstrated that several material systems are capable of withstanding extended periods of atomic oxygen exposure without undesirable performance degradation. Descriptions of the conceptual designs and materials test data are included.
Author

N88-19000*# Clarkson Univ., Potsdam, N.Y. Dept. of Electrical and Computer Engineering.
COMPUTER-AIDED MODELING AND PREDICTION OF PERFORMANCE OF THE MODIFIED LUNDELL CLASS OF ALTERNATORS IN SPACE STATION SOLAR DYNAMIC POWER SYSTEMS Semiannual Progress Report, 15 Aug. 1987 - 14 Feb. 1988
NABEEL A. O. DEMERDASH and REN-HONG WANG 15 Mar. 1988 62 p
(Contract NAG3-818)

(NASA-CR-182536; NAS 1.26:182536) Avail: NTIS HC A04/MF A01 CSCL 10B

The main purpose of this project is the development of computer-aided models for purposes of studying the effects of various design changes on the parameters and performance characteristics of the modified Lundell class of alternators (MLA) as components of a solar dynamic power system supplying electric energy needs in the forthcoming space station. Key to this modeling effort is the computation of magnetic field distribution in MLAs. Since the nature of the magnetic field is three-dimensional, the first step in the investigation was to apply the finite element method to discretize volume, using the tetrahedron as the basic 3-D element. Details of two rotator 3-D finite element grid are given. A preliminary look at the early stage of a 3-D rotor grid is presented. J.P.B.

08

ELECTRONICS

Includes descriptions of analytical techniques, analyses, systems, and requirements for internal and external communications, electronics, sensors for position and systems monitoring and antennas.

A88-11855#
APPLICATION OF ADVANCED AUTOMATION TECHNIQUES IN THE SPACE STATION ELECTRICAL POWER SYSTEM
WILLIAM H. ALLEN, ROBERT J. POEHLS, and THOMAS C. EVATT (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 514-521. refs

The Power Generation and Distribution System of the NASA Space Shuttle will feature autonomous, automatic control of the spacecraft's electrical power system in start-up, shut-down, source paralleling, peaking, energy storage management, source load sharing, voltage and frequency regulation, fault detection, and system health monitoring functions. Implementation of these functions is by means of closed-loop analog controls within local areas, and microprocessor control at higher levels. The global power control network will use a hierarchical set of microprocessor-based controllers to exercise overall system coordination, implementing adaptations of power analysis and control algorithms that have proven effective in terrestrial utility systems. O.C.

A88-11865*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
COAXIAL TUBE ARRAY SPACE TRANSMISSION LINE CHARACTERIZATION
COLLEEN A. SWITZER and DAVID J. BENTS (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 1. New York, American Institute of Aeronautics and Astronautics, 1987, p. 565-570. Previously announced in STAR as N87-22003.

The coaxial tube array tether/transmission line used to connect an SP-100 nuclear power system to the space station was characterized over the range of reactor-to-platform separation distances of 1 to 10 km. Characterization was done with respect to array performance, physical dimensions and masses. Using a fixed design procedure, a family of designs was generated for the same power level (300 kWe), power loss (1.5 percent), and meteoroid survival probability (99.5 percent over 10 yr). To differentiate between vacuum insulated and gas insulated lines, two different maximum values of the E field were considered: 20 kV/cm (appropriate to vacuum insulation) and 50 kV/cm (compressed SF6). Core conductor, tube, bumper, standoff, spacer and bumper support dimensions, and masses were also calculated. The results of the characterization show mainly how transmission line size and mass scale with reactor-to-platform separation distance. Author

A88-11912#
PARAMETRICS OF NICKEL-HYDROGEN CELL DESIGN
PETER J. DENONCOURT and ARNOLD M. HALL (Yardney Corp., Battery Div., Pawcatuck, CT) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 2. New York, American Institute of Aeronautics and Astronautics, 1987, p. 852-856.

A rigorous computer program for evaluating nickel-hydrogen LEO design trade-offs, including weight versus length versus diameter, in addition to the impact of electrode thickness and internal structure options is proposed. Construction parameters including maximum pressure, vessel thickness, stack dimensional details, and cost factors, are also taken into account. Specific weight and energy density considerations are used to study effectiveness trends for families of LEO designs. Data have been obtained with the program for cells of both 3 1/2 inch and 4 1/2 inch diameter sizes. R.R.

A88-12975
LISTENING TO THE COSMONAUTS
J. BRANEGAN Spaceflight (ISSN 0038-6340), vol. 29, Oct. 1987, p. 80-84.

The orbits typically made by the Mir Space Station in range of the U.K. are indicated schematically. Particular attention is given to where, when, and how these cosmonauts can be heard. The first requirement of the monitoring procedure is to set up a simple dipole aerial and a VHF receiver or a converter to an FM, CB receiver and then listen and tape record the signals. Among the events which can be heard are docold rescues, medical emergencies, EVA activities, and launch and docking. K.K.

A88-15285
CAMERA EXPERT SYSTEM FOR SPACE STATION COMMUNICATIONS AND TRACKING SYSTEM MANAGEMENT
MICHAEL CRONE and PAUL JULICH (Harris Corp., Melbourne, FL) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 14 p. refs

This paper describes research into the use of expert system technology for the management of the communications and tracking system for the Space Station. The CAMERA (Control and Monitor Equipment Resource Allocation) Expert System was developed to minimize crew workload in managing the communications of the Space Station. The system has been implemented (under NASA contract) for use on a testbed at JSC. The system utilizes a state-of-the-art man-machine interface to allow high-level end-to-end service requests. Author

A88-20350* Air Force Geophysics Lab., Hanscom AFB, Mass.
THE EFFECT OF PHOTOELECTRONS ON BOOM-SATELLITE POTENTIAL DIFFERENCES DURING ELECTRON BEAM EJECTION
SHU T. LAI, HERBERT A. COHEN (USAF, Geophysics Laboratory, Hanscom AFB, OH), THOMAS L. AGGSON (NASA, Goddard Space Flight Center, Greenbelt, MD), and WILLIAM J. MCNEIL (Radex, Inc., Lexington, MA) Journal of Geophysical Research (ISSN 0148-0227), vol. 92, Nov. 1, 1987, p. 12319-12325. refs
(Contract F19628-83-C-0105)
(AD-A190390; AFGL-TR-87-0336)

Data taken on the SCATHA satellite at geosynchronous altitudes during periods of electron beam ejection in sunlight showed that the potential difference between an electrically isolated boom and the satellite main body was a function of beam current, energy, and boom-sun angle. The potential difference decreased as the boom area illuminated by the sun increased; the maximum and minimum potential differences were measured when minimum and maximum boom areas, respectively, were exposed to the sun. It

is shown that photoelectrons, created on the boom, could be engulfed in the electrostatic field of the highly charged satellite main body. Theoretical calculations made using a simple current balance model showed that these electrons could provide a substantial discharging current to the main body and cause the observed variations in the potential difference between the main body and the booms. Author

A88-27542#
PROSPECTS ON FUTURE EVA COMMUNICATIONS
GERARD MARAL (Ecole Nationale Superieure des Telecommunications, Toulouse, France) IN: AIAA International Communication Satellite Systems Conference, 12th, Arlington, VA, Mar. 13-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 148-156.
(AIAA PAPER 88-0767)

This paper discusses a number of design approaches for an EVA communications system. The links to be established for an EVA communications subsystem facility and the conditions for EVA communications are identified. Issues for EVA communications are discussed, including compliance with radio regulations, considerations related to spherical coverage, and EVA communication network architecture. C.D.

A88-32189#
ANALYTICAL AND EXPERIMENTAL INVESTIGATIONS FOR SATELLITE ANTENNA DEPLOYMENT MECHANISMS
MASAYOSHI MISAWA, TETSUO YASAKA (Nippon Telegraph and Telephone Public Corp., Radio Communication Systems Laboratories, Kanagawa, Japan), and SHOJIRO MIYAKE (Nippon Telegraph and Telephone Public Corp., Applied Electronics Laboratories, Tokyo, Japan) IN: Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 116-124. refs
(AIAA PAPER 88-2225)

This paper deals with the prediction of deployment dynamics, antenna vibration characteristics, and reliability evaluation related to an antenna deployment mechanism (ADM) necessary for large satellite antenna development. A statistical analysis is proposed to predict the deployment dynamics of an antenna based on the driving and friction torques of mechanical parts whose statistical distributions are fitted to normal distributions. The effect of ADM bending stiffness on antenna natural frequencies was studied analytically to establish a guideline for determination of the ADM bending stiffness. The first natural frequency of the antenna was lessened by 5 Hz due to the effect of ADM bending stiffness. A procedure is proposed to evaluate the reliability of the ADM. Author

N88-10088*# National Aeronautics and Space Administration, Washington, D.C.
COMMUNICATION SATELLITE TECHNOLOGY TRENDS
LOUIS CUCCIA *In* NASA-Lewis Research Center, Spacecraft 2000 p 27-58 Jul. 1986
Avail: NTIS HC A11/MF A01 CSCL 22B

A chronology of space-Earth interconnectivity is presented. The Advanced Communications Technology Satellite (ACTS) system, Land Mobile Satellite, space-Earth antennas, impact of antenna size on coverage, intersatellite links are outlined. This presentation is represented by graphs and charts only. B.G.

N88-10220# Italspazio, Rome (Italy).
STUDY OF MOBILE COMMUNICATIONS PAYLOAD FOR COLUMBUS POLAR PLATFORMS Final Report
A. CRAMAROSSA, A. DENINNO, P. PALMUCCI, A. PANDOLFI, V. PILONI, G. RONDINELLI, and A. TUCZZI Paris, France ESA Dec. 1986 38 p
(Contract ESA-6606/85-F-RD(SC))
(ITS-TR-056A/86; ESA-CR(P)-2396; ETN-87-90530) Avail: NTIS HC A03/MF A01

A communication payload to be embarked on the Polar Platform of the Columbus program, to provide mobile communications services to the polar areas was defined. The time visibility constraints typical of the low altitude orbit of the platform are experienced by users and therefore limit the possibilities of real time operation. However, mail box type communications may be successfully implemented. The system architecture for a low orbit polar platform and the criteria for real time and mail box operations were derived. The system architecture includes the Earth segment and the in-orbit system. Problems relevant to the real viability of the in-orbit system were investigated, defining the service operation conditions and the communications transponder layout. The user terminal architecture was assessed to demonstrate overall program feasibility. ESA

N88-11732 European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
DISCHARGE PREVENTION OF GEOSYNCHRONOUS ORBIT CONDUCTIVE THERMAL CONTROL MATERIALS AND GROUNDING SYSTEMS
F. LEVADOU *In* CNES, Space Environment Technology p 695-715 Apr. 1987 In FRENCH; ENGLISH summary
Avail: CEPADUES-Editions, Toulouse, France

Research on the prevention of discharges in geosynchronous orbit for telecommunications and scientific satellites is summarized. Materials properties characterization, electrostatic discharge tests, grounding system development, and evaluation of materials and processes are discussed. ESA

N88-12030*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
WAVEFRONT ERROR SENSING
ELDRED F. TUBBS 15 Oct. 1986 15 p
(NASA-CR-181504; JPL-D-3722; NAS 1.26:181504; LDR-TM-86-2)
Avail: NTIS HC A03/MF A01 CSCL 20D

A two-step approach to wavefront sensing for the Large Deployable Reflector (LDR) was examined as part of an effort to define wavefront-sensing requirements and to determine particular areas for more detailed study. A Hartmann test for coarse alignment, particularly segment tilt, seems feasible if LDR can operate at 5 microns or less. The direct measurement of the point spread function in the diffraction limited region may be a way to determine piston error, but this can only be answered by a detailed software model of the optical system. The question of suitable astronomical sources for either test must also be addressed. M.G.

N88-12134# European Space Agency, Paris (France). Directorate of Telecommunications Programs.
INTEROPERABILITY AND INTEGRATION OF DATA RELAY SATELLITE SYSTEMS
G. BARRETTA *In its* Commercial Opportunities for Remote Sensing with Polar Platforms p 17-25 Apr. 1987
Avail: NTIS HC A05/MF A01

Interoperability of American, European and Japanese data relay satellite (DRS) networks is discussed, emphasizing the role of the Columbus space station. Six interoperability options, ranging from independently designed systems with S-band compatibility to systems which share frequencies and are fully coordinated, are presented. Antenna designs to prevent the LEO spacecraft body blocking the link between the LEO spacecraft antenna and the DRS location, are suggested. ESA

N88-13513*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
COMMUNICATIONS PAYLOAD CONCEPTS FOR GEOSTATIONARY FACILITIES
WILLIAM A. POLEY and JACK LEKAN Dec. 1987 96 p
(NASA-TM-100154; E-3353; NAS 1.15:100154) Avail: NTIS HC A05/MF A01 CSCL 17B

Summarized and compared are the major results of two NASA sponsored studies that defined potential communication payload concepts to meet the satellite traffic forecast for the turn of the century for the continental US and Region 2 of the International Telecommunications Union. The studies were performed by the

Ford Aerospace and Communications Corporation and RCA Astro-Electronics (now GE-RCA Astro-Space Division). Future scenarios of aggregations of communications services are presented. Payload concepts are developed and defined in detail for nine of the scenarios. Payload costs and critical technologies per payload are also presented. Finally the payload concepts are compared and the findings of the reports are discussed. Author

N88-14883*# Southern Univ., Baton Rouge, La. Coll. of Engineering.
AUTOMATIC ANTENNA SWITCHING DESIGN FOR EXTRA VEHICULAR ACTIVITY (EVA) COMMUNICATION SYSTEM Final Report
MANJIT S. RANDHAWA. *In* NASA. Lyndon B. Johnson Space Center, Houston, Tex. NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 2 20 p Nov. 1987
Avail: NTIS HC A15/MF A01 CSCL 17B

An Extra Vehicular Activity (EVA) crewmember had two-way communications with the space station in the Ku-band frequency (12 to 18 GHz). The maximum range of the EVA communications link with the space station is approximately one kilometer for nominal values for transmitter power, antenna gains, and receiver noise figure. The EVA Communications System, that will continue to function regardless of the astronaut's position and orientation, requires an antenna system that has full spherical coverage. Three or more antennas that can be flush mounted on the astronaut's space suit (EMU) and/or his propulsive backpack (MMU), will be needed to provide the desired coverage. As the astronaut moves in the space station, the signal received by a given EVA antenna changes. An automatic antenna switching system is needed that will switch the communication system to the antenna with the largest signal strength. A design for automatic antenna switching is presented and decussed. Author

N89-16794*# Ford Aerospace and Communications Corp., Palo Alto, Calif. Space Systems Div.
COMMUNICATIONS SATELLITE SYSTEMS OPERATIONS WITH THE SPACE STATION. VOLUME 3: SUPPLEMENTARY TECHNICAL REPORT Final Report, Feb. - Dec. 1987
K. M. PRICE, P. RUSSELL, and C. WEYANDT Feb. 1988 221 p
(Contract NAS3-24253)
(NASA-CR-180875; NAS 1.26:180875) Avail: NTIS HC A10/MF A01 CSCL 22B

The NASA space station has the potential to provide significant economic benefits to commercial communications satellite operators. The initial reports quantified the benefits of space-based activities and assessed the impacts on the satellite design and the space station. Results are given for the following additional tasks: quantify the value of satellite retrievability operations and define its operational aspects; evaluate the use of expendable launch vehicles for transportation of satellites from the Earth to the space station; and quantify the economic value of modular satellites that are assembled and serviced in space. Author

N88-18805*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPENSATION OF RELECTOR ANTENNA SURFACE DISTORTION USING AN ARRAY FEED
A. R. CHERRETTE, R. J. ACOSTA, P. T. LAM, and S. W. LEE (Illinois Univ., Urbana.) Jan. 1988 49 p
(Contract NAG3-419)
(NASA-TM-100286; E-3929; NAS 1.15:100286) Avail: NTIS HC A03/MF A01 CSCL 20N

The dimensional stability of the surface of a large reflector antenna is important when high gain or low sidelobe performance is desired. If the surface is distorted due to thermal or structural reasons, antenna performance can be improved through the use of an array feed. The design of the array feed and its relation to the surface distortion are examined. The sensitivity of antenna performance to changing surface parameters for fixed feed array geometries is also studied. This allows determination of the limits of usefulness for feed array compensation. Author

09

PROPULSION/FLUID MANAGEMENT

Includes descriptions, analyses, and subsystem requirements for propellant/fluid management and propulsion systems for attitude control and orbit maintenance and transfer for the station and supporting elements such as the OMV and OTV.

A88-15935#
SOLAR- AND NUCLEAR ELECTRIC PROPULSION FOR HIGH ENERGY ORBITS
H. W. LOEB (Giessen, Universitaet, Federal Republic of Germany) and H. BASSNER (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, Federal Republic of Germany) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 14 p. refs
(IAF PAPER 87-198)

A comparison is made between solar electric propulsion (SEP) and nuclear electric propulsion (NEP) in meeting the requirements for high energy orbits. The impact of power output on mission performance, the development status of the power sources, and the impact of those sources on the spacecraft design and mass are considered. The development of SEP and NEP hardware is described, and mission optimization with these technologies is discussed. C.D.

A88-15936#
SOLAR-THERMAL OTVS IN COMPARISON WITH ELECTRICAL AND CHEMICAL PROPULSION SYSTEMS
J. P. SCHLEINITZ and R. E. LO (DFVLR, Institut fuer Chemische Antriebe und Verfahrenstechnik, Hardthausen-Lampoldshausen, Federal Republic of Germany) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 11 p. refs
(IAF PAPER 87-199)

Different propulsion concepts for raising loads from LEO to GEO are compared. Chemical LOX/LH2-propulsion with and without aerobraking, electrostatic ion-propulsion, and electromagnetic MPD-thruster are compared with the concept of solar-thermal propulsion (STP). For the latter, special attention is given to the solar receiver. It is shown that, for a round-trip of up to 10 days, STP represents the most economically advantageous concept. For the receiver, the advanced particulate absorber system is found to be a very attractive concept. C.D.

A88-15937#
CONCEPT STUDIES FOR A LASER POWERED ORBITAL TRANSFER VEHICLE
ALAN BOND, ANTHONY R. MARTIN, and ROBERT A. BOND (U.K. Atomic Energy Authority, Culham Laboratory, Abingdon, England) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 23 p. refs
(IAF PAPER 87-200)

Concept studies for a continuous laser power system for application to the OTV are discussed, using the example of a vehicle powered by a 500 MW laser system, of which 300 MW is intercepted by the vehicle. Results lead to the prediction of a 25 km/s exhaust velocity. For a round trip mission with a velocity increment of 10 km/s, a vehicle with an initial mass of about 18 tons could propel a 7-ton payload from LEO to geostationary orbit and back. The time allotted for the mission would be of the same order as that of chemical systems, with times measured in hours rather than days. The vehicle could be deployed by a single Space Shuttle launch. R.R.

A88-15875*# Space Industries, Inc., Webster, Tex.
WATER-PROPELLANT RESISTOJETS FOR MAN-TENDED PLATFORMS
ALLEN J. LOUVIERE (Space Industries, Inc., Webster, TX), ROBERT E. JONES, W. EARL MORREN, and JAMES S. SOVEY (NASA, Lewis Research Center, Cleveland, OH) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 11 p. Previously announced in STAR as N87-26135. refs
(IAF PAPER 87-259)

The selection of a propulsion system for a man-tended platform has been influenced by the planned use of resistojets for drag make-up on the manned Space Station. For that application a resistojet has been designed that is capable of operation with a wide variety of propellants, including water. The reasons for the selection of water as the propellant and the performance of water as a propellant are discussed. The man-tended platform and its mission requirements are described. Author

A88-16021*# Michigan Univ., Ann Arbor.
OPTIMAL TIME FREE NODAL TRANSFERS BETWEEN ELLIPTICAL ORBITS
NGUYEN X. VINH, SHAU HERN KUO (Michigan, University, Ann Arbor), and CHRISTIAN MARCHAL (ONERA, Chatillon-sous-Bagneux, France) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 8 p. refs
(Contract JPL-956416)
(IAF PAPER 87-325)

The paper presents the necessary conditions for the minimum fuel, time-free transfer between two noncoplanar elliptical orbits. It is shown that the solution is obtained by solving a system of three nonlinear equations for three unknowns. The case where the impulses are applied along the line of nodes is discussed. In general, this nodal transfer is nonoptimal, but the characteristic velocity for the best nodal transfer, called the minimizing nodal transfer, is reasonably close to the one for the optimal transfer for it to be useful as a substitute for a practical transfer. Furthermore, when the relative position of the two terminal orbits is varied, the two characteristic velocities, for the minimizing nodal transfer and the optimal transfer, exhibit the same trend in the sense that they pass through their maxima and minima at nearly the same relative position. This makes the set of explicit formulas for computing the minimizing nodal transfer, as presented in this paper, a useful tool for designing a minimum fuel transfer between several orbits. Author

A88-21255* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
SPACE STATION PROPULSION SYSTEM TECHNOLOGY
ROBERT E. JONES, PHILLIP R. MENG, STEVEN J. SCHNEIDER, JAMES S. SOVEY, and ROBERT R. TACINA (NASA, Lewis Research Center, Cleveland, OH) Acta Astronautica (ISSN 0094-5765), vol. 15, Sept. 1987, p. 673-683. Previously announced in STAR as N87-25422. refs

Two propulsion systems have been selected for the Space Station: O/H rockets for high thrust applications and the multipropellant resistojets for low thrust needs. These thruster systems integrate very well with the fluid systems on the station. Both thrusters will utilize waste fluids as their source of propellant. The O/H rocket will be fueled by electrolyzed water and the resistojets will use stored waste gases from the environmental control system and the various laboratories. This paper presents the results of experimental efforts with O/H and resistojet thrusters to determine their performance and life capability. Author

A88-22707
PARTICLE BED REACTOR PROPULSION VEHICLE PERFORMANCE AND CHARACTERISTICS AS AN OPBITAL TRANSFER ROCKET
F. L. HORN, J. R. POWELL, and O. W. LAZARETH (Brookhaven National Laboratory, Upton, NY) IN: Space nuclear power systems 1986; Proceedings of the Third Symposium, Albuquerque, NM, Jan. 13-16, 1986. Malabar, FL, Orbit Book Co., Inc., 1987, p. 375-381. USAF-sponsored research.

The general design of a particle bed reactor producing 100-300 MW power output using hydrogen as a coolant and capable of specific impulses of up to 1000 seconds as a nuclear rocket is described. The performance of the reactor as an OTV is analyzed with reference to five basic missions, and it is shown that a nuclear-powered OTV increases payloads for GEO and extra-GEO missions by a factor of 2-3 in comparison with a chemical hydrogen-oxygen rocket. The nuclear OTV enables new extra-GEO missions to be performed, including parking in ultrahigh orbits and returning to GEO with a spare satellite, as well as transfer to retrograde GEO orbits upon command. V.L.

A88-22708
SPACE BASED NUCLEAR-MICROWAVE ELECTRIC PROPULSION
GERALD D. NORDLEY (USAF, Rocket Propulsion Laboratory, Edwards AFB, CA) and WILLIAM C. BROWN IN: Space nuclear power systems 1986; Proceedings of the Third Symposium, Albuquerque, NM, Jan. 13-16, 1986. Malabar, FL, Orbit Book Co., Inc., 1987, p. 383-395. refs

The concept of using a space-based nuclear power facility to generate and beam power at microwave frequencies to a spacecraft equipped with a suitable receiver and an electric propulsion system for orbital transfer is examined. The state-of-the-art technology needed for space-based beamed microwave power transmission is summarized, and some of the cost/performance tradeoffs involved are discussed in a preliminary manner. Recommended areas for further research are outlined. V.L.

A88-27888#
SLOSH DYNAMICS IN A TOROIDAL TANK
J. S. MESEROLE and A. FORTINI (Boeing Aerospace Co., Seattle, WA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, Nov.-Dec. 1987, p. 523-531. Previously cited in issue 20, p. 2942, Accession no. A86-42808. refs

A88-29236
TWO DAYS TO MARS WITH FUSION PROPULSION
MARSHA FREEMAN Twenty-first Century Science and Technology (ISSN 0895-6820), vol. 1, Mar.-Apr. 1988, p. 26-31.

The ideal propulsion system for the manned journey from earth to Mars is one that combines high thrust generation with very high specific impulse; it is presently suggested that only fusion power can maximize both of these parameters to the point where the interplanetary journey in question can be made in several days rather than, as at present, several months. A vehicle accelerating at 1g half of the way to Mars, and then decelerating at the same rate for the remainder of the journey, would require a fusion power plant of 1-terawatt output, or three orders of magnitude greater than the 1-gigawatt output of the largest terrestrial fission powerplants. O.C.

N88-10104*# Rockwell International Corp., Canoga Park, Calif. Propulsion Programs.
SPACE STATION PROPULSION TECHNOLOGY: SPACE STATION PROPULSION SYSTEM TEST BED TEST PLAN
G. L. BRILEY 22 Sep. 1986 55 p
(Contract NAS8-36418)
(NASA-CR-179201; NAS 1.26:179201) Avail: NTIS HC A04/MF A01 CSCL 21H

Testing of the hydrogen/oxygen Space Station Propulsion System will demonstrate the technology readiness for the IOC application. To facilitate early demonstration of this technology and to allow demonstration of maturing technology, this testing will be performed with the components installed on a test bed which simulated the Space Station Structure. The test plan contains a description of the test bed, test objective, instrumentation plan, and controls plan. Each of these is discussed in detail. B.G.

N88-11072*# National Aerospace Lab., Amsterdam (Netherlands). Space Div.
A PRELIMINARY STUDY OF A FLUID SCIENCE LABORATORY FOR SPACE STATION (COLUMBUS). PART 4: EXECUTIVE SUMMARY Final Report
I. DARIVA, I. MARTINEZ, R. MARTINEZ-VAL, A. SANZ, R. H. HUIJSER, F. B. VISSER, and J. P. B. VREEBURG. Paris, France ESA 30 Jan. 1987 40 p
(Contract ESA-6506/85-F-FL(SC))
(NLR-TR-87023-L-PT-4; ESA-CR(P)-2437-PT-4; ETN-87-90893)
Avail: NTIS HC A03/MF A01

The scientific background, techniques, and facilities for a microgravity fluid science laboratory (FSL) on Columbus are outlined. The FSL provides for self-contained experiment cells, for on-orbit configuration of liquid, including continuous flow experiments, and allows accommodation of unspecified facilities. It consists of two double racks, LEDR and REDR. The REDR is equipped with a cold loop (working temperature minus 15 C) to thermostat the TGC and optional cold ends. The loop pump and thermostat (refrigerator) are in the climatization fluid service station. Loop temperature regulation conforms to thermographic cavity requirements. The LEDR has a heat dump loop to cool equipment and to allow quenches. Loop temperature is coarsely regulated, fine control is to be realized at the experiment (Peltier elements). ESA

N88-11746*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACE STATION PROPULSION
ROBERT E. JONES, W. EARL MORREN, JAMES S. SOVEY, and ROBERT R. TACINA. 1987 19 p. Presented at the 1987 JANNAF Propulsion Conference, San Diego, Calif., 15-17 Dec. 1987
(NASA-TM-100216; E-3825; NAS 1.15:100216) Avail: NTIS HC A03/MF A01 CSCL 21H

Two propulsion systems have been selected for the space station: gaseous H/O rockets for high thrust applications and the multipropellant resistojets for low thrust needs. These two thruster systems integrate very well with the fluid systems on the space station, utilizing waste fluids as their source of propellant. The H/O rocket will be fueled by electrolyzed water and the resistojets will use waste gases collected from the environmental control system and the various laboratories. The results are presented of experimental efforts with H/O and resistojet thrusters to determine their performance and life capability, as well as results of studies to determine the availability of water and waste gases. Author

N88-11750*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A LIFE TEST OF A 22-NEWTON (5-LBF) HYDRAZINE ROCKET
P. R. MENG, S. J. SCHNEIDER, C. J. MORGAN, R. E. JONES, and D. A. PAHL (Rocket Research Corp., Redmond, Wash.) 1987 12 p. Prepared for presentation at the JANNAF Propulsion Conference, San Diego, Calif., 15-17 Dec. 1987
(NASA-TM-100232; E-3857; NAS 1.15:100232) Avail: NTIS HC A03/MF A01 CSCL 21H

Life tests were conducted on a 22-N (5-lb) hydrazine rocket thruster which incorporates the latest technology to obtain long life from the catalyst bed. A spring mechanism surrounding the catalyst bed continually applies compression to the catalyst bed to prevent the formation of any void channels. The research rocket thruster was tested over an operational cycle of both steady state and pulse firing which simulated a possible space station duty cycle. The thruster ran as expected for about 40 hours, or 3.2 times 10 to the 6th power N-sec (7.2 times 10 to the 5th power lb-sec) total impulse. Subsequently, some thrust chamber pressure decreases were noted during long steady state test periods. After 60.2 hours of run time, tests had to be terminated due to a blockage in the propellant injector tube which occurred during heating of the thruster by a heat lamp. A chemical analysis of the catalyst indicated that iron and nickel metals had poisoned some of the catalyst, thereby causing a degradation in performance. It was determined that a contaminated barrel of hydrazine was the source of the metal poisoning. Author

N88-11753*# Martin Marietta Aerospace, Denver, Colo.
SPACE STATION INTEGRATED PROPULSION AND FLUID SYSTEM STUDY: FLUID SYSTEMS CONFIGURATION DATABOOK
L. ROSE, B. BICKNELL, D. BERGMAN, and S. WILSON. 9 Jul. 1987 99 p
(Contract NAS8-36438)
(NASA-CR-179215; NAS 1.26:179215; MCR-87-578; EP-2.1)
Avail: NTIS HC A05/MF A01 CSCL 21H

This databook contains fluid system requirements and system descriptions for Space Station program elements including the United States and International modules, integrated fluid systems, attached payloads, fluid servicers and vehicle accommodation facilities. Separate sections are devoted to each of the program elements and include a discussion of the overall system requirements, specific fluid systems requirements and systems descriptions. The systems descriptions contain configurations, fluid inventory data and component lists. In addition, a list of information sources is referenced at the end of each section. M.G.

N88-12528*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MICROGRAVITY COMBUSTION FUNDAMENTALS
KURT R. SACKSTEDER. *In its* Spacecraft Fire Safety p 89-94 1987
Avail: NTIS HC A07/MF A01 CSCL 22A

A brief summary of some of the important physical processes involved in low gravity combustion is given. While the discussion is generally limited to the processes involved in the combustion of continuous, solid, nonmetallic fuels, much of the reasoning presented can be applied to other fuel types and configurations. Author

N88-12530*# National Aeronautics and Space Administration. White Sands Test Facility, N. Mex.
IGNITION AND COMBUSTION OF METALS IN OXYGEN
FRANK J. BENZ and S. ZHU (Lockheed Engineering and Management Services Co., Inc., Las Cruces, N. Mex.) *In* NASA, Lewis Research Center, Spacecraft Fire Safety p 99-102 1987
Avail: NTIS HC A07/MF A01 CSCL 11F

Tests in which metals were rubbed against themselves in oxygen have revealed that increasing oxygen pressure does not always increase the potential for ignition. It is believed that there exists a specific pressure above which convective heat loss due to higher oxygen density will overcome the potential increase in the oxidation rate afforded by the increase in oxygen pressure. Test results have shown that, once a specific oxygen pressure is exceeded, greater rates of frictional energy were required for ignition of metals as pressure is increased. Other test results have indicated that as oxygen pressure is increased during the rubbing process, the bulk sample equilibrium temperatures decrease. These results support the belief that increases in convective heat loss as pressure is increased can raise the energy requirements for ignition of metals or lower their ignition potentials. Testing has also indicated that, when metals were exposed to a rubbing process and oxygen pressure was increased, metals such as carbon steel exhibited a decrease in their bulk ignition temperatures, whereas metals such as Monel showed bulk ignition temperatures independent of pressure. Author

N88-12538*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPATABILITY OF DISPERSION-STRENGTHENED PLATINUM WITH RESISTOJET PROPELLANTS
MARGARET V. WHALEN and MICHAEL V. NATHAL. Oct. 1987 29 p
(NASA-TP-2765; E-3738; NAS 1.60:2765) Avail: NTIS HC A03/MF A01 CSCL 21H

Resistojets for the Space Station require long life and multipropellant capability. The choice of available materials to meet

these requirements is limited. Dispersion-strengthened platinum was selected. Past results indicated that it should be sufficiently inert in candidate propellant environments and should be capable of operating at moderate temperatures for extended periods. A series of propellant compatibility tests was done with platinum strengthened with either yttria or zirconia. Data presented included the results of 1000-hr tests in CO2, H2, ammonia (NH3), N2, steam, hydrazine (N2H4), and methane (CH4); and 2000-hr tests in H2 and NH3. The platinum samples were tested at 1400 C in CO2, H2, NH3, N2, steam, and N2H4; at 500 C in CH4; and at 800 C in N2H4. The mass-loss results indicated material life, extrapolated from experimental mass-loss data, in excess of 100 000 hr in all environments except steam and N2H4, where it was greater than or = 45000 hr. Generally, on the basis of mass loss, there were no compatibility concerns in any of the environments considered. Optical and scanning electron microscopy were used to determine the effect of propellants on the material surface and to evaluate material stability. Author

N88-12541*# Rocketdyne Div., Rockwell International Corp., Canoga Park, Calif.
SPACE STATION RESISTOJET SYSTEM REQUIREMENTS AND INTERFACE DEFINITION STUDY Final Report, Jun. 1986 - Jun. 1987
L. E. FINDEN Nov. 1987 120 p
(Contract NAS3-24658)
(NASA-CR-180832; NAS 1.26:180832; RI/RD-87-211) Avail: NTIS HC A06/MF A01 CSCL 21H

A conceptual design study of the resistojet orbital replacement unit (ORU) was conducted. The ORU consists of four 500-W multipropellant resistojets, fluid components downstream of the waste fluid storage subsystem, a power controller, structure, and micrometeorite shielding. The fluid components include latch valves, a water vaporizer, two pressure regulators or flow control valves, filters, check valves, fluid tubing, and interface couplings. Separate fluid components are provided for oxidizing fluids, reducing fluids and water. Different flow and power control methods were studied. The most promising methods consist of a constant pressure/on-off power control and a constant power/variable pressure control. The closed-loop power control incorporates a feedback signal which is proportional to resistojet heater temperature. Author

N88-15006*# Martin Marietta Aerospace, Denver, Colo.
SPACE STATION ONBOARD PROPULSION SYSTEM: TECHNOLOGY STUDY Final Report
J. G. MCALLISTER, R. S. RUDLAND, L. R. REDD, D. H. BEEKMAN, S. M. CUFFIN, C. M. BEER, and K. K. MCCARTHY Jan. 1987 106 p
(Contract NAS3-23893)
(NASA-CR-179233; NAS 1.26:179233; MCR-87-500) Avail: NTIS HC A06/MF A01 CSCL 21H

The objective was to prepare for the design of the space station propulsion system. Propulsion system concepts were defined and schematics were developed for the most viable concepts. A dual mode bipropellant system was found to deliver the largest amount of payload. However, when resupply is considered, an electrolysis system with 10 percent accumulators requires less resupply propellant, though it is penalized by the amount of time required to fill the accumulators and the power requirements for the electrolyzer. A computer simulation was prepared, which was originally intended to simulate the water electrolysis propulsion system but which was expanded to model other types of systems such as cold gas, monopropellant and bipropellant storable systems. J.P.B.

N88-15835*# Rocketdyne Div., Rockwell International Corp., Canoga Park, Calif.
SPACE STATION PROPULSION TECHNOLOGY Annual Progress Report No. 2, 24 May 1986 - 2 Oct. 1987
A. M. NORMAN, G. L. BRILEY, and S. A. EVANS 8 Oct. 1987 34 p
(Contract NAS8-36418)
(NASA-CR-179260; NAS 1.26:179260) Avail: NTIS HC A03/MF A01 CSCL 21H

The objectives of this program are to provide a demonstration of hydrogen/oxygen propulsion technology readiness for the initial operational capability (IOC) space station application, specifically gaseous hydrogen/oxygen and warm hydrogen thruster concepts, and to establish a means for evolving from the IOC space station propulsion system (SSPS) to that required to support and interface with advanced station functions. These objectives were met by analytical studies and by furnishing a propulsion test bed to the Marshall Space Flight Center for testing. Author

N88-15924*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CRYOGENIC FLUID MANAGEMENT TECHNOLOGY WORKSHOP. VOLUME 1: PRESENTATION MATERIAL AND DISCUSSION
JOHN C. AYDELOTT, ed. and WILLIAM DEVOL, ed. (Sverdrup Technology, Inc., Middleburg Heights, Ohio.) Sep. 1987 386 p Workshop held in Cleveland, Ohio, 28-30 Apr. 1987
(NASA-CP-10001; E-3732; NAS 1.55:10001) Avail: NTIS HC A17/MF A01 CSCL 20D

The major objective of the workshop was to identify future NASA needs for technology that will allow the management of subcritical cryogenic fluids in the low gravity space environment. Workshop participants were asked to identify those technologies which will require in-space experimentation and are thus candidates for inclusion in the flight experiment being defined at the Lewis Research Center.

N88-15925*# Air Force Astronautics Lab., Edwards AFB, Calif.
AF CRYOGENIC AND FLUID MANAGEMENT SPACECRAFT TECHNOLOGY PROGRAM
ROY SILVER *In* NASA. Lewis Research Center, Cleveland, Ohio. Cryogenic Fluid Management Technology Workshop. Volume 1: Presentation Material and Discussion p 7-20 Sep. 1987
Avail: NTIS HC A17/MF A01 CSCL 20D

Viewgraphs are given that outline the program objectives of long term cryogenic storage programs. Diagrams of the orbit transfer vehicle, thermal insulation blankets, cryogenic storage tanks, the advanced liquid feed experiment, and the acoustic measurement on satellite experiment are presented. The objectives, goals, and payoffs of the fluid management space experiment and the liquid droplet radiator are outlined. R.J.F.

N88-15932*# General Dynamics Corp., San Diego, Calif. Space Systems Div.
LARGE CAPACITY CRYOPROPELLANT ORBITAL STORAGE FACILITY
J. R. SCHUSTER *In* NASA. Lewis Research Center, Cleveland, Ohio. Cryogenic Fluid Management Technology Workshop. Volume 1: Presentation Material and Discussion p 151-174 Sep. 1987
Avail: NTIS HC A17/MF A01 CSCL 21I

A comprehensive study was performed to develop the major features of a large capacity orbital propellant storage facility for the space-based cryogenic orbital transfer vehicle. Projected propellant usage and delivery schedules can be accommodated by two orbital tank sets of 100,000 lb storage capacity, with advanced missions expected to require increased capacity. Information is given on tank pressurization schemes, propellant transfer configurations, pump specifications, the refrigeration system, and flight tests. R.J.F.

N88-15933*# Analex Corp., Fairview Park, Ohio.
SPACE ENVIRONMENTAL CONSIDERATIONS FOR A LONG-TERM CRYOGENIC STORAGE VESSEL
SHIGEO NAKANISHI *In* NASA. Lewis Research Center, Cleveland, Ohio. Cryogenic Fluid Management Technology Workshop. Volume 1: Presentation Material and Discussion p 175-191 Sep. 1987
Avail: NTIS HC A17/MF A01 CSCL 20D

Information is given on the kind of protection that is needed against impact and perforation of a long-term cryogenic storage

vessel in space by meteoroids and space debris. The long-term effects of the space environment on thermal control surfaces and coatings, and the question of whether the insulation and thermal control surfaces should be encased in a vacuum jacket shell are discussed. R.J.F.

N88-17717*# Martin Marietta Aerospace, New Orleans, La.
STS PROPELLANT SCAVENGING SYSTEMS STUDY. PART 2, VOLUME 2: COST AND WBS/DICTIONARY Final Report
FRANK L. WILLIAMS Jun. 1987 72 p
(Contract NAS8-35614)
(NASA-CR-179276; NAS 1.26:179276) Avail: NTIS HC A04/MF A01 CSCL 22B

Presented are the results of the cost analysis performed to update and refine the program phase C/D cost estimates for a Shuttle Derived Vehicle (SDV) tanker. The SDV tanker concept is an unmanned cargo vehicle incorporating a set of propellant tanks in the vehicle's payload module. The tanker will be used to meet the demand for a cryogenic propellant supply in orbit. The propellant tanks are delivered to a low Earth orbit or to an orbit in the vicinity of the Space Station. The intent of the economic analysis is to provide NASA with economic justification for the propellant scavenging concept that minimizes the total Space Transportation System life cycle cost. The detailed costs supporting the concept selection process are presented with descriptive text to aid in forecasting the phase C/D project and program planning. Included are all propellant scavenging costs as well as all SDV, STS and Orbital Maneuvering Vehicle charges to deliver the propellants to the Space Station. F.M.R.

N88-17728*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MAGNETIC EMISSIONS TESTING OF THE SPACE STATION ENGINEERING MODEL RESISTOJET
DANIEL BRIEHL Feb. 1988 11 p
(NASA-TM-100788; E-3961; NAS 1.15:100788) Avail: NTIS HC A03/MF A01 CSCL 22B

The engineering model resistojet intended for altitude maintenance onboard the space station was tested for magnetic radiation emissions in the Radio Frequency Interference (RFI) facility at the Goddard Space Flight Center. The resistojet heater was supplied with power at 20 kHz and low voltage through a power controller. The resistojet was isolated from its power supply in the RFI enclosure, and the magnetic emission measured at three locations around the resistojet at various heater currents. At a heater current of 18.5 A the maximum magnetic emission was 61 dBpt at a distance of 1 m from the resistojet and at a location at the rear of the thruster. Calculations indicate that the case and heat shields provided a minimum of 4 dB of attenuation at a current of 18.5 A. Maximum radiation was measured at the rear of the resistojet along its major axis and was thought to be due to the magnetic radiation from the power leads. At a distance of 37 cm from the resistojet the maximum magnetic radiation measured was 73 dBpt at a current of 11.2 A. The power input leads were also a source of magnetic radiation. The engineering model resistojet requires about 20 dB of additional shielding. Author

N88-17731*# Sverdrup Technology, Inc., Cleveland, Ohio.
COMPONENT DATA BASE FOR SPACE STATION RESISTOJET AUXILIARY PROPULSION Final Report
CLAYTON H. BADER Jan. 1988 62 p Microfiche included as supplement
(Contract NAS3-24105)
(NASA-CR-180834; E-3856; NAS 1.26:180834) Avail: NTIS HC A04/MF A01 CSCL 21H

The resistojet was baselined for Space Station auxiliary propulsion because of its operational versatility, efficiency, and durability. This report was conceived as a guide to designers and planners of the Space Station auxiliary propulsion system. It is directed to the low thrust resistojet concept, though it should have application to other station concepts or systems such as the Environmental Control and Life Support System (ECLSS), Manufacturing and Technology Laboratory (MTL), and the Waste Fluid Management System (WFMS). The information will likely be quite useful in the same capacity for other non-Space Station systems including satellite, freeflyers, explorers, and maneuvering vehicles. The report is a catalog of the most useful information for the most significant feed system components and is organized for the greatest convenience of the user. Author

10

MECHANISMS, AUTOMATION, AND ARTIFICIAL INTELLIGENCE

Includes descriptions of simulations, models, analytical techniques, and requirements for remote, automated and robotic mechanical systems.

A88-12526
AIAA COMPUTERS IN AEROSPACE CONFERENCE, 6TH, WAKEFIELD, MA, OCT. 7-9, 1987, TECHNICAL PAPERS
Conference sponsored by AIAA. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, 397 p. For individual items see A88-12527 to A88-12579.

Papers are presented on the analysis of Ada as a prototyping language; the evaluation of a dual processor implementation for a fault inferring nonlinear detection system; fault-tolerant systems; intelligent interfaces to aircraft systems; the implementation of a research prototype on a fault monitoring and diagnosis system; future data acquisition capabilities; and the application of AI technology to the analysis and synthesis of reliable software systems. Topics discussed include the 'spaceplane's astronaut's associate'; model-based health monitoring for reusable launch vehicles; Space Shuttle telemetry analysis by a real-time expert system; avionics, AI, and embedded processing systems; methodology requirements for intelligent systems architecture; and commonsense reasoning and superconductivity for self-replicating telerobots. Consideration is given to autonomous spacecraft operations, semiautonomous control for satellite servicing, and expert system control for airborne radar surveillance. I.F.

A88-12571#
AUTONOMOUS SPACECRAFT OPERATIONS - PROBLEMS AND SOLUTIONS
PHILIP C. DALEY and ALLISON L. THORNBRUGH (Martin Marietta Corp., Astronautics Group, Denver, CO) IN: AIAA Computers in Aerospace Conference, 6th, Wakefield, MA, Oct. 7-9, 1987, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 332-336. refs
(Contract F30602-86-C-0062)
(AIAA PAPER 87-2850)

In view of the utility projected for AI in NASA Space Station and SDI-related spacecraft operations, an evaluation is made of the systems engineering and acquisition management aspects of spaceborne knowledge-based system (KBS) components. Space platform testing, validation and verification methods, as well as management methods and procedures, must be modified in light of the unique characteristics of KBSs. Functional pipelining is suggested to be the basis of solutions for many problems encountered in the tradeoff between KBS verification, on the one hand, and the complexity and functionality of spacecraft systems, on the other. O.C.

A88-12573#
SEMIAUTONOMOUS CONTROL FOR SATELLITE SERVICING
SHELDON OXENBERG, ROBERT RUSSELL (RCA Advanced Technology Laboratories, Moorestown, NJ), STEVEN RAYMUS (RCA, Astro-Space Div., Princeton, NJ), and LARRY ALEXANDER (Digital Equipment Corp., Landover, MD) IN: AIAA Computers in Aerospace Conference, 6th, Wakefield, MA, Oct. 7-9, 1987,

Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 344-352.
(AIAA PAPER 87-2852)

A semiautonomous telerobotic system for satellite servicing that incorporates a number of advanced technologies has been developed. The system features structured supervisory control software that guides the operator through a step-by-step script and gracefully accommodates transitions between manual and automatic control. Other major features include voice input/output for both camera and robot control, model-based path planning, shared control with active compliance, and a two-actuator standard integrated connector. These features will allow a single operator to control the exchange of an orbital replacement unit from a remote location. Demonstrations of the system in June 1987 at NASA's Goddard Space Flight Center all resulted in the flawless performance of a simulated orbital replacement unit exchange.
Author

A88-14996
ON THE MODELLING AND CONTROL OF A FLEXIBLE MANIPULATOR ARM BY POINT ACTUATORS
A. G. CHASSIAKOS and G. A. BEKEY (Southern California, University, Los Angeles, CA) IN: IEEE Conference on Decision and Control, 25th, Athens, Greece, Dec. 10-12, 1986, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 1145-1150. refs

In this paper the modeling and control of a single-link manipulator with link flexibility is discussed. A linear state-space model is obtained and a controller is proposed with the actuators and measurements located at points along the length of the arm. Also a method for the optimal selection of the controllers' locations is presented, so that bending is minimized during the arm motion. The results are validated by simulations.
Author

A88-15284
DESIGN AND DEVELOPMENT OF A COMPUTER-ASSISTED GROUND CONTROL TECHNIQUE FOR SPACE STATION ROBOTICS
CARL R. KONKEL and PHILLIP E. HARMON (Teledyne Brown Engineering, Huntsville, AL) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 17 p.

Recent design activities for the International Space Station have included studies of the operations and productivity of the U.S. Laboratory module. A major finding was that the most limited resource on the Station will be crew time. A ground-controlled robot has been proposed that will help alleviate these constraints and allow around-the-clock U.S. Laboratory operations. However, the ground control of a mechanism in earth orbit imposes command and feedback delays because of the distance and communications network involved. A unique predictive display for use by the ground operator in the presence of varying time delays has been developed and tested and has reduced the 'move-and-wait' task times normally associated with delayed feedback teleoperations, minimized operator training, and reduced downlink bandwidth required.
Author

A88-15289
THE CANADIAN MOBILE SERVICING SYSTEM FOR SPACE STATION SERVICING
DEV M. GOSSAIN (Spar Aerospace, Ltd., Remote Manipulator Systems Div., Toronto, Canada) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 7 p.

The Mobile Servicing System (MSS) concept is being developed as the Canadian contribution to the Space Station Program. The MSS is a major element of the servicing architecture in the Space Station Program and complements the role of U.S. developed Servicing Facility on the Station. This paper describes the servicing functions performed by MSS. These functions include servicing of attached payloads as well as assembly and maintenance of the Station. Robotic servicing requirements have also been addressed. The architecture and concepts of MSS and its constituent systems are described.
Author

A88-15300* National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.
BUILDING INTELLIGENT SYSTEMS - ARTIFICIAL INTELLIGENCE RESEARCH AT NASA AMES RESEARCH CENTER
PETER FRIEDLAND and HENRY LUM (NASA, Ames Research Center, Moffett Field, CA) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 7 p.

The basic components that make up the goal of building autonomous intelligent systems are discussed, and ongoing work at the NASA Ames Research Center is described. It is noted that a clear progression of systems can be seen through research settings (both within and external to NASA) to Space Station testbeds to systems which actually fly on the Space Station. The starting point for the discussion is a 'truly' autonomous Space Station intelligent system, responsible for a major portion of Space Station control. Attention is given to research in fiscal 1987, including reasoning under uncertainty, machine learning, causal modeling and simulation, knowledge from design through operations, advanced planning work, validation methodologies, and hierarchical control of and distributed cooperation among multiple knowledge-based systems.
B.J.

A88-15813#
POTENTIALS OF ROBOTIC OPERATIONS ON BOARD THE MAN-TENDED FREE-FLYER
E.-L. RUNGELHOEFER and J. PULS (DFVLR, Cologne, Federal Republic of Germany) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 9 p. refs
(IAF PAPER 87-17)

Applications of automation and robotics technology on board the Man-Tended Free-Flyer (MTFF), an element of the Columbus program, are examined. In particular, attention is given to the definition of automation and robotics hardware components, servicing during manned and payload operation phases, and robotic operation. The operation of manipulators is discussed with reference to operational modes and requirements (e.g., microgravity, safety, and kinematics). Finally, some recommendations concerning the MTFF development are given.
V.L.

A88-15816*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NASA'S TELEROBOTICS R & D PROGRAM - STATUS AND FUTURE DIRECTIONS
DONNA SHIRLEY PIVIROTTO (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) and GIULIO VARSI (NASA, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 8 p. refs
(Contract NAS7-918)
(IAF PAPER 87-24)

NASA's telerobotics technology program is described as well as the process for the transfer of this technology to the Space Station, and some of the implications of the technology for station design and operations, including those for international cooperation. A diagram is presented of the NASREM control hierarchy with the Office of Aeronautics and Space Technology telerobot testbed architecture superimposed. In telerobotics, the following areas were identified as possible subjects for developing data to support international standards: (1) task boards, (2) system performance measures on task boards, (3) human performance measures on task boards with teleoperation, and (4) autonomous-telerobotic-telecperated performance comparisons.
K.K.

A88-15817*# National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Md.
THE FLIGHT TELEROBOTIC SERVICER (FTS) - A FOCUS FOR AUTOMATION AND ROBOTICS ON THE SPACE STATION

SANFORD W. HINKAL, JAMES F. ANDARY, JAMES G. WATZIN, and DAVID E. PROVOST (NASA, Goddard Space Flight Center, Greenbelt, MD) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 9 p. refs
(IAF PAPER 87-25)

The concept, fundamental design principles, and capabilities of the FTS, a multipurpose telerobotic system for use on the Space Station and Space Shuttle, are discussed. The FTS is intended to assist the crew in the performance of extravehicular tasks; the telerobot will also be used on the Orbital Maneuvering Vehicle to service free-flyer spacecraft. The FTS will be capable of both teleoperation and autonomous operation; eventually it may also utilize ground control. By careful selection of the functional architecture and a modular approach to the hardware and software design, the FTS can accept developments in artificial intelligence and newer, more advanced sensors, such as machine vision and collision avoidance. V.L.

A88-15819#
TELEROBOTICS AND ORBITAL LABORATORIES - AN END-TO-END ANALYSIS AND DEMONSTRATION
CARL R. KONKEL (Teledyne Brown Engineering, Huntsville, AL) and CRAIG F. MILLER (Intellidex, Inc., Corvallis, OR) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 7 p. refs
(IAF PAPER 87-27)

Concepts for a Laboratory Experiment Manipulator system consisting of an onboard mobile manipulator and a computer-assisted operator control station are discussed, with application to the International Space Station. A unique predictive display for data evaluation is considered as a solution to the problem of robot remote control in the presence of time delay. Correction factors for the calibration of the robot predictor model have been incorporated such as geometric distortion and spherical aberration caused by the video optics. The onboard manipulator concept has been demonstrated experimentally using an industrial robot, with operator joystick command capability and delayed video feedback included to simulate the Space Station Teleoperation system. R.R.

A88-15822#
APPLICABILITY OF A.I. TECHNIQUES TO THE SPACE STATION, A STUDY CASE - DEVELOPMENT OF AN EXPERT SYSTEM FOR ON BOARD FAULT MANAGEMENT
R. PERSICO, P. DONZELLI, F. LONGONI (Laben - Industrie per lo Spazio e le Comunicazioni S.p.A., Vimodrone, Italy), and G. ROCCA (Quinary, Milan, Italy) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 7 p. refs
(IAF PAPER 87-30)

Results are presented from a feasibility study of AI fault diagnosis aboard the Space Station. The evolution of AI capabilities in recent years is reviewed, the main goals of AI development for the Space Station are outlined, and specific tasks for expert systems in the crew work station are discussed, including system and subsystem operation and management, payload operation and management, support for telescience and active research, and mission planning and timelining. An expert-system architecture is then worked out for the case of the Processor Interface Adaptor; the methodological approach, knowledge base, inference engine, user interface, and development environment definition are characterized in detail and illustrated with diagrams. The architecture developed is found to be a first step in (1) reducing crew workload while maintaining crew authority and visibility and (2) meeting hardware documentation needs. T.K.

A88-15823*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
PROGRESS TOWARDS AUTONOMOUS, INTELLIGENT SYSTEMS
HENRY LUM (NASA, Ames Research Center, Moffett Field, CA) and EWALD HEER (Heer Associates, Inc., LaCanada, CA) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 12 p. refs
(IAF PAPER 87-31)

An aggressive program has been initiated to develop, integrate, and implement autonomous systems technologies starting with today's expert systems and evolving to autonomous, intelligent systems by the end of the 1990s. This program includes core technology developments and demonstration projects for technology evaluation and validation. This paper discusses key operational frameworks in the context of systems autonomy applications and then identifies major technological challenges, primarily in artificial intelligence areas. Program content and progress made towards critical technologies and demonstrations that have been initiated to achieve the required future capabilities in the year 2000 era are discussed. Author

A88-16309
MODELLING AND SIMULATION OF DISTRIBUTED FLEXIBILITY IN A SPACEBORNE MANIPULATOR
J. P. CHRETIEN, M. DELPECH, and A. LOUHMADI (Toulouse, Centre d'Etudes et de Recherches, France) IN: Automatic control in space 1985. Oxford and New York, Pergamon Press, 1986, p. 269-277. refs
(Contract CNES-82-0766; CNES-83-721)

The modal impedance, assumed-mode, and fictitious joint-introduction approaches to the characterization of distributed flexibility are evaluated for the case of an in-plane, two-degrees-of-freedom manipulator. General, multipurpose software for the geometric, kinematic, and dynamic analysis of rigid multibody mechanical systems is used. The introduction of fictitious joints is used to solve problems associated with simulation, kinematic inversion, and closed-loop analysis. O.C.

A88-16313
CONTROL ASPECTS OF A EUROPEAN SPACE MANIPULATOR SYSTEM
W. VAN LEEUWEN (Fokker, Schiphol, Netherlands) IN: Automatic control in space 1985. Oxford and New York, Pergamon Press, 1986, p. 303-309.

The aim of this study was to review existing design techniques for robots on the matter of their applicability for the design and development of a space manipulator system. Attention is paid to the definition and the design approach of the overall control system. Special emphasis is given to the control elements dealing with task-definition, path construction, and on-board control. Also, a number of on-board implementation aspects are considered. Furthermore, a comparison is made with the Remote Manipulator Control, as used on the Space Shuttle. Author

A88-16999* Stanford Univ., Calif.
EXPERIMENTS IN ADVANCED CONTROL CONCEPTS FOR SPACE ROBOTICS - AN OVERVIEW OF THE STANFORD AEROSPACE ROBOTICS LABORATORY
M. G. HOLLARS, R. H. CANNON, JR., H. L. ALEXANDER, and D. F. MORSE (Stanford University, CA) IN: Guidance and control 1987; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Jan. 31-Feb. 4, 1987. San Diego, CA, Univelt, Inc., 1987, p. 417-434. NASA-supported research. refs
(Contract F49620-82-C-00092; F33615-85-C-5106; F33615-82-K-5108; MDA903-86-K-0037)
(AAS PAPER 87-044)

The Stanford University Aerospace Robotics Laboratory is actively developing and experimentally testing advanced robot control strategies for space robotic applications. Early experiments focused on control of very lightweight one-link manipulators and other flexible structures. The results are being extended to position and force control of mini-manipulators attached to flexible manipulators and multilink manipulators with flexible drive trains. Experimental results show that end-point sensing and careful dynamic modeling or adaptive control are key to the success of these control strategies. Free-flying space robot simulators that operate on an air cushion table have been built to test control

strategies in which the dynamics of the base of the robot and the payload are important. Author

A88-17000* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE TELEROBOTICS TECHNOLOGY DEMONSTRATION PROGRAM
S. Z. SZIRMAY, P. S. SCHENKER, G. RODRIGUEZ, and R. L. FRENCH (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Guidance and control 1987; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Jan. 31-Feb. 4, 1987. San Diego, CA, Univelt, Inc., 1987, p. 435-444. refs
(AAS PAPER 87-045)

The paper reports the ongoing development of a telerobot demonstrator. The demonstrator is implemented as a laboratory-based research testbed, and will show proof-of-concept for supervised automation of space assembly, servicing, and repair operations. The demonstrator system features a hierarchically layered intelligent control architecture which enables automated planning and run-time sequencing of complex tasks by a supervisory human operator. The demonstrator also provides a full bilateral force-reflecting hand control teleoperations capability. The operator may switch smoothly between the automated and teleoperated tasking modes in run-time, either on a preplanned or operator-designated basis. Author

A88-19864
ROBOTS - AUTONOMOUS SPACE WORKERS
D. R. SLOGGETT Space (ISSN 0267-954X), vol. 3, Nov.-Dec. 1987, p. 6-10.

Crew safety, increased capability, and productivity drive the potential applications for robots in space. Enhanced astronaut safety, due to the reduced need for EVA, coupled with the ability to deal safely with malfunctions that cause hazardous conditions in the vicinity of the failed equipment are the main goals of using robots in space. In order to operate in space, the robots must be hardened against high energy particles, small meteorites, and radiation. NASA-sponsored work has shown the need to support features such as gross and dexterous manipulation, handling flexible objects, execution of 'learned' sequences, and multiarm operations. The use of intelligent robots on the Space Station is discussed. K.K.

A88-21631
SPACE STATION AUTOMATION II; PROCEEDINGS OF THE MEETING, CAMBRIDGE, MA, OCT. 28-30, 1986
WUN C. CHIOU, SR., ED. (Lockheed Research Laboratories, Palo Alto, CA) Meeting sponsored by SPIE. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings, Volume 729), 1987, 275 p. For individual items see A88-21632 to A88-21666.
(SPIE-729)

Various papers on Space Station (SS) automation are presented. Individual topics addressed include: automation and robotics for the SS; controlling real-time processes on the SS with expert sytems; communicating expert systems in fault diagnosis for SS applications; automatic planning research applied to orbital construction; NASA systems autonomy demonstration program; autonomy, automation, and systems; autonomous management of the SS electric energy system; design knowledge capture for the SS; translation and execution of distributed Ada programs; knowledge-based mission sequencing; passive optically encoded transponder; orbiting control station for free-flying teleoperators; system architecture for telerobotic servicing and assembly tasks. Also discussed are: computing architecture for telerobots in earth orbit; NASA telerobot technology demonstrator; launching a commercial space industry; Solar Maximum Mission repair; implementation of expert system technology on the SS; video-based satellite attitude determination; cooperative human-machine fault diagnosis. C.D.

A88-21632* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
USE OF AUTOMATION AND ROBOTICS FOR THE SPACE STATION
AARON COHEN (NASA, Johnson Space Center, Houston, TX) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 2-6.

An overview is presented of the various possible applications of automation and robotics technology to the Space Station system. The benefits of such technology to the private sector and the national economy are addressed. NASA's overall approach to incorporating advanced technology into the Space Station is examined. C.D.

A88-21634
CONTROLLING REAL-TIME PROCESSES ON THE SPACE STATION WITH EXPERT SYSTEMS
DAVID LERNWEBER (LISP Machine, Inc., Manhattan Beach, CA) and JOHN PERRY (OAO, Inc., El Segundo, CA) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 11-29. refs

This paper describes the requirements for real-time expert systems in Space Station control, and presents prototype implementations of Space Station expert control procedures in process intelligent control (PICON). PICON is a real-time expert system shell which operates in parallel with distributed data acquisition systems. It incorporates a specialized inference engine with a specialized scheduling portion specifically designed to match the allocation of system resources with the operational requirements of real-time control systems. Innovative knowledge engineering techniques used in PICON to facilitate the development of real-time sensor-based expert systems using special features of the inference engine are illustrated. C.D.

A88-21638
THE DISTRIBUTED AI SYSTEM FOR THE DYNAMIC ALLOCATION AND MANAGEMENT OF POWER (DAISY-DAMP) TESTBED
PETER C. OHLER and STEVEN B. HALL (Lockheed Missiles and Space Co., Inc., Astronautics Div., Sunnyvale, CA) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 67-78. refs

DAISY-DAMP is a prototype of an avant-garde electrical power control system. Although the system is still in the early stages of its development a number of interesting design characteristics are beginning to emerge. Two of the most significant of these features are discussed here. The first has to do with the structure of the system as a set of cooperating agents. The second has to do with the utility, in this domain, of a developmental testbed as a tool for exploring the relevant design space. The utilization of testbeds to explore the potential applicability of recent advances in temporal reasoning and machine learning to subsystem control problems of this sort is also discussed. Author

A88-21639* Texas Christian Univ., Fort Worth.
NASA SYSTEMS AUTONOMY DEMONSTRATION PROGRAM - A STEP TOWARD SPACE STATION AUTOMATION
S. A. STARKS (Texas Christian University, Fort Worth), D. RUNDUS (South Florida, University, Tampa, FL), W. K. ERICKSON (NASA, Ames Research Center, Moffett Field, CA), and K. J. HEALEY (NASA, Johnson Space Center, Houston, TX) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 80-85.

This paper addresses a multiyear NASA program, the Systems Autonomy Demonstration Program (SADP), whose main objectives include the development, integration, and demonstration of automation technology in Space Station flight and ground support systems. The role of automation in the Space Station is reviewed, and the main players in SADP and their roles are described. The

core research and technology being promoted by SADP are discussed, and a planned 1988 milestone demonstration of the automated monitoring, operation, and control of a complete mission operations subsystem is addressed. C.D.

A88-21640* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AUTONOMY, AUTOMATION, AND SYSTEMS
PHILIP R. TURNER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 86-89. refs

Automation technologies which support autonomy in artificial intelligence systems are discussed. The motivation for system control architecture is reviewed, and the concept of an operating system for autonomous control is examined. Design requirements for complex automated systems are summarized, and system engineering tool applications in design support are discussed. C.D.

A88-21646* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
THE USE OF COMPUTER GRAPHIC SIMULATION IN THE DEVELOPMENT OF ON-ORBIT TELE-ROBOTIC SYSTEMS
KEN FERNANDEZ and ELAINE HINMAN (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 146-154. refs

This paper describes the use of computer graphic simulation techniques to resolve critical design and operational issues for robotic systems used for on-orbit operations. These issues are robot motion control, robot path-planning/verification, and robot dynamics. The major design issues in developing effective telerobotic systems are discussed, and the use of ROBOSIM, a NASA-developed computer graphic simulation tool, to address these issues is presented. Simulation plans for the Space Station and the Orbital Maneuvering Vehicle are presented and discussed. C.D.

A88-21648* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
A TECHNIQUE TO AID IN THE DESIGN OF OPTIMAL ROBOTS FOR USE IN SPACE APPLICATIONS
GERALD ROSTON (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 161-164. refs

A method is presented which gives robot designers a starting point for designing 'optimal' robots for space applications. Test results on a robot kinematically similar to a Puma 560 are summarized, indicating the inadequacies of current kinematic design. The work that still needs to be done to achieve a full, working system is described. C.D.

A88-21649* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SYSTEM ARCHITECTURE FOR TELEROBOTIC SERVICING AND ASSEMBLY TASKS
F. WALLACE HARRISON, JR. and JACK E. PENNINGTON (NASA, Langley Research Center, Hampton, VA) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 165-171. refs

The architecture of an integrated telerobotics laboratory which is being used for research on the mechanisms, controls, sensing, and operator interface required to accomplish space telerobotic tasks is described. The laboratory hardware is considered, including manipulator and controller, end effector, and vision. The virtual architecture, a common reference model for most of the laboratory applications, is discussed. Teleoperator and robotics system simulations which have been performed using the system are discussed. C.D.

A88-21651* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE NASA TELEROBOT TECHNOLOGY DEMONSTRATOR
P. S. SCHENKER, R. L. FRENCH, A. R. SIROTA, and J. R. MATIJEVIC (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 179-188. refs

The ongoing development of a telerobot technology demonstrator is reported. The demonstrator is implemented as a laboratory-based research testbed, and will show proof-of-concept for supervised automation of space assembly, servicing, and repair operations. The demonstrator system features a hierarchically layered intelligent control architecture which enables automated planning and run-time sequencing of complex tasks by a supervisory human operator. The demonstrator also provides a full bilateral force-reflecting hand control teleoperations capability. The operator may switch smoothly between the automated and teleoperated tasking modes in run-time, either on a preplanned or operator-designated basis. Author

A88-21655
IMPACT OF INTELLIGENT SYSTEMS ON SPACE STATION MAN-MACHINE INTERFACE (MMI) DESIGN
PAMELA G. JAMAR and ANNE SCHUR (Honeywell Systems and Research Center, Minneapolis, MN) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 218-224. refs

Supervisory control tasks define a new set of requirements for Space Station MMI design: (1) multifunction display and control hardware; (2) displays that enhance the crew persons' 'mental model' of invisible processes; (3) highly supportive man-machine dialog, including special features to support dialog with expert systems; (4) incorporation of machine intelligence into the MMI itself to provide a seemingly uniform interface to numerous processes, data bases, and expert systems; and (5) electronic documentation. A discussion of these concepts is illustrated by examples from recent MMI designs, including a multifunction display and control system developed for the Space Shuttle, an MMI system developed for NASA JSC for the Space Station environmental control and life support system, ATOZ - an intelligent interface system, and VIMAD - an electronic documentation system for maintenance procedures. Author

A88-21656* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THEORETICAL CONSIDERATIONS IN DESIGNING OPERATOR INTERFACES FOR AUTOMATED SYSTEMS
SUSAN D. NORMAN (NASA, Ames Research Center, Moffett Field, CA) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 225-230.

The domains most amenable to techniques based on artificial intelligence (AI) are those that are systematic or for which a systematic domain can be generated. In aerospace systems, many operational tasks are systematic owing to the highly procedural nature of the applications. However, aerospace applications can also be nonprocedural, particularly in the event of a failure or an unexpected event. Several techniques are discussed for designing automated systems for real-time, dynamic environments, particularly when a 'breakdown' occurs. A breakdown is defined as operation of an automated system outside its predetermined, conceptual domain. Author

A88-21659* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
COOPERATIVE HUMAN-MACHINE FAULT DIAGNOSIS

ROGER REMINGTON and EVERETT PALMER (NASA, Ames Research Center, Moffett Field, CA) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 253-259. refs

Current expert system technology does not permit complete automatic fault diagnosis; significant levels of human intervention are still required. This requirement dictates a need for a division of labor that recognizes the strengths and weaknesses of both human and machine diagnostic skills. Relevant findings from the literature on human cognition are combined with the results of reviews of aircrew performance with highly automated systems to suggest how the interface of a fault diagnostic expert system can be designed to assist human operators in verifying machine diagnoses and guiding interactive fault diagnosis. It is argued that the needs of the human operator should play an important role in the design of the knowledge base. Author

A88-22332*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
TELESCIENCE TESTBEDDING FOR LIFE SCIENCE MISSIONS ON THE SPACE STATION
D. RASMUSSEN (NASA, Ames Research Center, Moffett Field, CA), A. MIAN (RCA, New York), and J. BOSLEY (NASA, Ames Research Center; Bionetics Corp., Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 6 p. refs
(AIAA PAPER 88-0446)

'Telescience', defined as the ability of distributed system users to perform remote operations associated with NASA Space Station life science operations, has been explored by a developmental testbed project allowing rapid prototyping to evaluate the functional requirements of telescience implementation in three areas: (1) research planning and design, (2) remote operation of facilities, and (3) remote access to data bases for analysis. Attention is given to the role of expert systems in telescience, its use in realistic simulation of Space Shuttle payload remote monitoring, and remote interaction with life science data bases. O.C.

A88-24230* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
PROCESSES IN CONSTRUCTION OF FAILURE MANAGEMENT EXPERT SYSTEMS FROM DEVICE DESIGN INFORMATION
JANE T. MALIN and NICK LANCE (NASA, Johnson Space Center, Houston, TX) IEEE Transactions on Systems, Man, and Cybernetics (ISSN 0018-9472), vol. SMC-17, Nov.-Dec. 1987, p. 956-967. refs

This paper analyzes the tasks and problem solving methods used by an engineer in constructing a failure management expert system from design information about the device to be diagnosed. An expert test engineer developed a trouble-shooting expert system based on device design information and experience with similar devices, rather than on specific expert knowledge gained from operating the device or troubleshooting its failures. The construction of the expert system was intensively observed and analyzed. This paper characterizes the knowledge, tasks, methods, and design decisions involved in constructing this type of expert system, and makes recommendations concerning tools for aiding and automating construction of such systems. Author

A88-24239* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
INTELLIGENT SYSTEMS AND ROBOTICS FOR AN EVOLUTIONARY SPACE STATION
JON D. ERICKSON (NASA, Johnson Space Center, Houston, TX) British Interplanetary Society, Journal (Mission Automation Systems) (ISSN 0007-084X), vol. 40, Oct. 1987, p. 471-481. refs

The Space Station will be a multipurpose space facility to acquire and exploit unique knowledge with a planned lifetime of greater than 20 years. It will include laboratories for science and manufacturing, provide a platform for earth and interplanetary observations, conduct satellite servicing, and serve as a transportation node for potential manned geosynchronous, lunar, and Mars missions. Environmental safety considerations and limited manpower resources require the extensive use of intelligent systems and flexible robotics on the Space Station. Design accommodations must be planned in advance to allow incorporation of these advancing technologies on the evolutionary Space Station. Author

A88-26575#
DEVELOPMENT OF A MASTER SLAVE MANIPULATOR SYSTEM FOR SPACE USE
YOSHITSUGU TODA, KAZUO MACHIDA, TOSHIAKI IWATA, and MASAKUNI KAWADA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 35, no. 406, 1987, p. 546-553. In Japanese, with abstract in English. refs

A generalized master slave manipulator system which was assumed to operate near/or around the Space Station was developed. A standardized serial communication line was used between the master and the slave manipulator. The master manipulator was designed to be self-balanced to simulate operation under the zero-gravity condition. A force/torque reflecting bilateral control using the force-torque sensor settled at the wrist of the slave manipulator was adopted. An experiment in which the slave manipulator was in a vacuum chamber was performed, within restricted sight of cameras set up in the chamber. The problems which would result from adopting a generalized master slave manipulator system were almost solved, except for the delay caused by the calculation time. Author

A88-27355* Pennsylvania State Univ., University Park.
INFORMATION PRIORITIZATION FOR CONTROL AND AUTOMATION OF SPACE OPERATIONS
ASOK RAY (Pennsylvania State University, University Park), SURESH M. JOSHI (NASA, Langley Research Center, Hampton, VA), CYNTHIA K. WHITNEY (Charles Stark Draper Laboratory, Inc., Cambridge, MA), and HONG N. JOW (Yankee Atomic Electric Co., Framingham, MA) IN: 1987 American Control Conference, 6th, Minneapolis, MN, June 10-12, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1987, p. 958-960. refs

The applicability of a real-time information prioritization technique to the development of a decision support system for control and automation of Space Station operations is considered. The steps involved in the technique are described, including the definition of abnormal scenarios and of attributes, measures of individual attributes, formulation and optimization of a cost function, simulation of test cases on the basis of the cost function, and examination of the simulation scenarios. A list is given comparing the intrinsic importances of various Space Station information data. C.D.

A88-31274
AN INITIAL STUDY OF REMOTELY MANIPULATED STUD WELDING FOR SPACE APPLICATIONS
K. MASUBUCHI, A. IMAKITA, and M. MIYAKE (MIT, Cambridge, MA) Welding Journal (ISSN 0043-2296), vol. 67, April 1988, p. 25-34. refs

Technical information generated during a research program for advancing the technology of welding in space is presented. The technical background to this research is reviewed, the stud welding process is outlined, and the experimental apparatus is described. The reported results show that stud welding in vacuum is possible for an AL6061 plate with AL5000 studs, an AL2219 plate with AL2319 studs, and an SUS304 plate with SUS305 studs. The alloy AL2219 shows promising experimental results for space application. C.D.

N88-10090*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TELEROBOTICS
DONNA L. PIVIROTTO In NASA-Lewis Research Center, Spacecraft 2000 p 71-75 Jul. 1986
Avail: NTIS HC A11/MF A01 CSCL 13I

This presentation summarizes NASA's future plans and current technology programs for telerobotics and is represented by charts. Author

N88-10341# MATRA Espace, Paris-Velizy (France). Space Branch.
ROBOTIC SENSORS AND ACTUATORS FOR A SERVICE MANIPULATOR SYSTEM. VOLUME 1: EXECUTIVE SUMMARY Final Report
TH. BLAIS, J. L. LACOMBE, G. BERGER, G. CLEMENT, U. HILZENBECHER, and J. DELTORO (Sener, S.A., Madrid, Spain) Paris, France ESA Jun. 1986 62 p Original contains color illustrations
(Contract ESA-5739/83-NL-AN(SC))
(MATRA-EPT/DT/VT187/120; ESA-CR(P)-2403-VOL-1; ETN-87-90536) Avail: NTIS HC A04/MF A01

The state of the art of robotics, telemanipulation, and servicing was reviewed in order to develop a service manipulator system (SMS) for in-orbit servicing. An SMS concept is described. Development activities and test requirements in vision systems, control techniques, end effector grapple mechanisms, force/torque sensors, and hinge joints are outlined. A development plan is presented. ESA

N88-10342# MATRA Espace, Paris-Velizy (France). Space Branch.
ROBOTIC SENSORS AND ACTUATORS FOR A SERVICE MANIPULATOR SYSTEM. VOLUME 2: SERVICE MANIPULATOR SYSTEM (SMS) HANDBOOK Final Report
TH. BLAIS, J. L. LACOMBE, G. BERGER, G. CLEMENT, U. HILZENBECHER, and J. DELTORO (Sener, S.A., Madrid, Spain) Paris, France ESA Jun. 1986 113 p
(Contract ESA-5739/83-NL-AN(SC))
(MATRA-EPT/DT/VT187/227; ESA-CR(P)-2403-VOL-2; ETN-87-90537) Avail: NTIS HC A06/MF A01

A service manipulator system (SMS) for in-orbit servicing is described. The mechanical characteristics, electrical architecture, sensors, control system, software, thermal control, mass/power/communication budgets, and SMS mass distribution, reference frames, and flight segment are presented. The SMS specifications, quality assurance provisions, and preparation for delivery are outlined. ESA

N88-10343# MATRA Espace, Paris-Velizy (France). Space Branch.
ROBOTIC SENSORS AND ACTUATORS FOR A SERVICE MANIPULATOR SYSTEM. VOLUME 3, PHASE A REPORT AND PROGRAM PLAN Final Report
TH. BLAIS, J. L. LACOMBE, G. BERGER, G. CLEMENT, U. HILZENBECHER, and J. DELTORO (Sener, S.A., Madrid, Spain) Paris, France ESA Jun. 1986 233 p
(Contract ESA-5739/83-NL-AN(SC))
(MATRA-EPT/DT/VT187/228; ESA-CR(P)-2403-VOL-3; ETN-87-90538) Avail: NTIS HC A11/MF A01

The state of the art of robotics, telemanipulation, and servicing was reviewed in order to develop a service manipulator system (SMS) for in-orbit servicing. An SMS concept is described. Development activities and test requirements in vision systems, control techniques, end effector grapple mechanisms, force/torque sensors, and hinge joints are outlined. A development plan is presented. ESA

N88-10346# Oak Ridge National Lab., Tenn.
TRACTION-DRIVE SEVEN DEGREES-OF-FREEDOM TELEROBOT ARM: A CONCEPT FOR MANIPULATION IN SPACE
D. P. KUBAN and D. M. WILLIAMS 1987 21 p Presented at the 21st Aerospace Mechanisms Symposium, Houston, Tex., 29 Apr. 1987
(Contract DE-AC05-84OR-21400)
(DE87-010895; CONF-8704161-1) Avail: NTIS HC A03/MF A01

As man seeks to expand his dominion into new environments, the demand increases for machines that perform useful functions in remote locations. This new concept for manipulation in space is based on knowledge and experience gained from manipulator systems developed to meet the needs of remote nuclear applications. It merges the best characteristics of teleoperation and robotic technologies. This paper summarizes the report of a study performed for NASA Langley Research Center. The design goals for the telerobot, a mechanical description, and technology areas that must be addressed for successful implementation will be presented and discussed. The concept incorporates mechanical traction drives, redundant kinematics, and modular arm subelements to provide a backlash-free manipulator capable of obstacle avoidance. Further development of this arm is in progress at the Oak Ridge National Laboratory. DOE

N88-10489# British Aerospace Public Ltd. Co., Stevenage (England). Space and Communications Div.
TELEOPERATION AND CONTROL STUDY Final Report
J. S. SHEPPARD, comp. Paris, France ESA Nov. 1986 556 p
(Contract ESA-6118/84)
(BAE-TP-8268; ESA-CR(P)-2413; ETN-87-90549) Avail: NTIS HC A24/MF A01

Requirements for a servicing manipulator teleoperator system were derived using two mission model scenarios. The first scenario introduces the problem of communication time delays within the overall manipulator teleoperator control system, associated with the human operator being located on the ground while controlling a manipulator on a free-flying servicing vehicle, servicing a payload on a platform or satellite docked to it, in low Earth orbit. The second scenario has the human operator located on the shuttle aft deck controlling a manipulator servicing a payload in the cargo area. This scenario is intended to demonstrate the operational capability of the service manipulator system using the Robotic Servicing Experiment. A ground based supervisor is also assumed for this mission, permitting a teleoperation-control experiment with time delay, to be performed as required. It is concluded that true teleoperation and control of a remote manipulator cannot be readily achieved in the presence of a communications time delay. ESA

N88-12105*# Alabama Univ., Huntsville.
TELEOPERATOP AND ROBOTICS SYSTEM ANALYSIS Final Report
WILLIAM TEOH 30 Sep. 1987 243 p
(Contract NAS8-35670)
(NASA-CR-179220; NAS 1.26:179220) Avail: NTIS HC A11/MF A01 CSCL 13I

The Orbital Maneuvering Vehicle (OMV) was designed to operate as a remotely controlled space teleoperator. The design and implementation of OMM (a mathematical model of the OMV) are discussed. The State Vector Transformation Module (SVX), an interface between the OMV simulation model and the mobile base (TOM-B) of the flat floor simulation system is described. A summary of testing procedures and conclusions are presented together with the test data obtained. R.G.

N88-12342*# Research Triangle Inst., Research Triangle Park, N.C.
POTENTIAL APPLICATIONS OF EXPERT SYSTEMS AND OPERATIONS RESEARCH TO SPACE STATION LOGISTICS FUNCTIONS
THOMAS F. LIPPIATT and DONALD WATERMAN Jun. 1985 73 p
(Contract NAS10-10438)
(NASA-CR-180473; NAS 1.26:180473; N-2315-NASA) Avail: NTIS HC A04/MF A01 CSCL 12B

The applicability of operations research, artificial intelligence, and expert systems to logistics problems for the space station were assessed. Promising application areas were identified for space station logistics. A needs assessment is presented and a specific course of action in each area is suggested. B.G.

N88-13908*# Catholic Univ. of America, Washington, D.C. Dept. of Electrical Engineering.
CARTESIAN PATH CONTROL OF A TWO-DEGREE-OF-FREEDOM ROBOT MANIPULATOR Semiannual Report
CHARLES C. NGUYEN and FARHAD J. POORAN Jan. 1988 24 p
(Contract NAG5-780)
(NASA-CR-182331; NAS 1.26:182331) Avail: NTIS HC A03/MF A01 CSCL 09B

The problem of cartesian trajectory control of a closed-kinematic chain mechanism robot manipulator with possible space station applications is considered. The study was performed by both computer simulation and experimentation for tracking of three different paths: a straight line, a sinusoid and a circle. Linearization and pole placement methods are employed to design controller gains. Results show that the controllers are robust and there are good agreements between simulation and experimentation. Excellent tracking quality and small overshoots are also evident. Author

N88-14876*# Texas A&I Univ., Kingsville. Dept. of Civil and Mechanical Engineering.
DYNAMICS, CONTROL AND SENSOR ISSUES PERTINENT TO ROBOTIC HANDS FOR THE EVA RETRIEVER SYSTEM Final Report
ROBERT A. MCLAUCHLAN *In* NASA, Lyndon B. Johnson Space Center, Houston, Tex. NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 2 20 p Nov. 1987
Avail: NTIS HC A15/MF A01 CSCL 13I

Basic dynamics, sensor, control, and related artificial intelligence issues pertinent to smart robotic hands for the Extra Vehicular Activity (EVA) Retriever system are summarized and discussed. These smart hands are to be used as end effectors on arms attached to manned maneuvering units (MMU). The Retriever robotic systems comprised of MMU, arm and smart hands, are being developed to aid crewmen in the performance of routine EVA tasks including tool and object retrieval. The ultimate goal is to enhance the effectiveness of EVA crewmen. Author

N88-15196*# Alabama Univ., Huntsville
PERSONNEL OCCUPIED WOVEN ENVELOPE ROBOT POWER Semiannual Report
30 Nov. 1987 115 p Prepared in cooperation with Pace and Waite, Inc., Huntsville, Ala. and Wyle Labs., Inc., Huntsville, Ala.
(Contract NAGW-847)
(NASA-CR-182367; NAS 1.26:182367) Avail: NTIS HC A06/MF A01 CSCL 14B

The Human Occupied Space Teleoperator (HOST) system currently under development utilizes a flexible tunnel/Stewart table structure to provide crew access to a pressurized manned work station or POD on the space station without extravehicular activity (EVA). The HOST structure facilitates moving a work station to multiple space station locations. The system has applications to orbiter docking, space station assembly, satellite servicing, space station maintenance, and logistics support. The conceptual systems design behind HOST is described in detail. J.P.B.

N88-15497*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
INTEGRATION OF SYMBOLIC AND ALGORITHMIC HARDWARE AND SOFTWARE FOR THE AUTOMATION OF SPACE STATION SUBSYSTEMS
HUGH GREGG, KATHLEEN HEALEY, EDMUND HACK, and CARLA WONG (National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.) Oct. 1987 9 p Presented at the 3rd Conference on Artificial Intelligence for Space Applications, Huntsville, Ala., 2 Nov. 1987
(Contract W-7405-ENG-48)
(NASA-TM-89705; NAS 1.26:89705; DE88-002386; UCRL-97570; CONF-871182-1) Avail: NTIS HC A02/MF A01 CSCL 09B

Traditional expert systems, such as diagnostic and training systems, interact with users only through a keyboard and screen, and are usually symbolic in nature. Expert systems that require access to data bases, complex simulations and real-time instrumentation have both symbolic as well as algorithmic computing needs. These needs could both be met using a general purpose workstation running both symbolic and algorithmic code, or separate, specialized computers networked together. The latter approach was chosen to implement TEXSYS, the thermal expert system, developed by NASA Ames Research Center in conjunction with Johnson Space Center to demonstrate the ability of an expert system to autonomously monitor the thermal control system of the space station. TEXSYS has been implemented on a Symbolics workstation, and will be linked to a microVAX computer that will control a thermal test bed. This paper will explore the integration options, and present several possible solutions. DOE

N88-15815*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
ADVANCING AUTOMATION AND ROBOTICS TECHNOLOGY FOR THE SPACE STATION AND FOR THE US ECONOMY: SUBMITTED TO THE UNITED STATES CONGRESS OCTOBER 1, 1987 Progress Report No. 5, 16 May - 30 Sep. 1987
Sep. 1987 46 p
(NASA-TM-100777; NAS 1.15:100777) Avail: NTIS HC A03/MF A01 CSCL 22A

In April 1985, as required by Public Law 98-371, the NASA Advanced Technology Advisory Committee (ATAC) reported to Congress the results of its studies on advanced automation and robotics technology for use on the space station. This material was documented in the initial report (NASA Technical Memorandum 87566). A further requirement of the Law was that ATAC follow NASA's progress in this area and report to Congress semiannually. This report is the fifth in a series of progress updates and covers the period between 16 May 1987 and 30 September 1987. NASA has accepted the basic recommendations of ATAC for its space station efforts. ATAC and NASA agree that the mandate of Congress is that an advanced automation and robotics technology be built to support an evolutionary space station program and serve as a highly visible stimulator affecting the long-term U.S. economy. Author

N88-15817*# National Aeronautics and Space Administration, Washington, D.C.
ADVANCING AUTOMATION AND ROBOTICS TECHNOLOGY FOR THE SPACE STATION AND FOR THE US ECONOMY: SUBMITTED TO THE UNITED STATES CONGRESS MAY 15, 1987 Progress Report No. 4, Oct. 1986 - 15 May 1987
May 1987 61 p
(NASA-TM-89811; NAS 1.15:89811) Avail: NTIS HC A04/MF A01 CSCL 22A

In April 1985, as required by Public Law 98-371, the NASA Advanced Technology Advisory Committee (ATAC) reported to Congress the results of its studies on advanced automation and robotics technology for use on the space station. This material was documented in the initial report (NASA Technical Memorandum 87566). A further requirement of the Law was that ATAC follow NASA's progress in this area and report to Congress semiannually. This report is the fourth in a series of progress updates and covers the period October 1, 1986 to May 15, 1987. NASA has accepted the basic recommendations of ATAC for its space station efforts. ATAC and NASA agree that the will of Congress is to build an advanced automation and robotics technology base that will support an evolutionary space station program and serve as a highly visible stimulator affecting the long-term U.S. economy. The progress report identifies the work of NASA and the space station study contractors, research in progress, and issues connected with the advancement of automation and robotics technology on the space station. Author

N88-15818*# National Aeronautics and Space Administration, Washington, D.C.
ADVANCING AUTOMATION AND ROBOTICS TECHNOLOGY FOR THE SPACE STATION AND FOR THE US ECONOMY: SUBMITTED TO THE UNITED STATES CONGRESS OCTOBER 1, 1986 Progress Report No. 3, Apr. - Sep. 1986
Sep. 1986 58 p
(NASA-TM-89190; NAS 1.15:89190) Avail: NTIS HC A04/MF A01 CSCL 22A

In April 1985, as required by Public Law 98-371, the NASA Advanced Technology Advisory Committee (ATAC) reported to Congress the results of its studies on advanced automation and robotics technology for use on the space station. This material was documented in the initial report (NASA Technical Memorandum 87566). A further requirement of the Law was that ATAC follow NASA's progress in this area and report to Congress semiannually. This report is the third in a series of progress updates and covers the period between April 1, 1986 and September 30, 1986. NASA has accepted the basic recommendations of ATAC for its space station efforts. ATAC and NASA agree that the will of Congress is to build an advanced automation and robotics technology base that will support an evolutionary space station program and serve as a highly visible stimulator affecting the long-term U.S. economy. The progress report identifies the work of NASA and the space station study contractors, research in progress, and issues connected with the advancement of automation and robotics technology on the space station. Author

N88-16360*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
THIRD CONFERENCE ON ARTIFICIAL INTELLIGENCE FOR SPACE APPLICATIONS, PART 1
JUDITH S. DENTON, comp., MICHAEL S. FREEMAN, comp., and MARY VEREEN, comp. Nov. 1987 421 p Conference held in Huntsville, Ala., 2-3 Nov. 1987, sponsored by NASA, Marshall Space Flight Center, Huntsville, Ala. and Alabama Univ., Huntsville
(NASA-CP-2492-Pt-1; M-575-PT-1; NAS 1.55:2492-Pt-1) Avail: NTIS HC A18/MF A01 CSCL 09B

The application of artificial intelligence to spacecraft and aerospace systems is discussed. Expert systems, robotics, space station automation, fault diagnostics, parallel processing, knowledge representation, scheduling, man-machine interfaces and neural nets are among the topics discussed.

N88-16370*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
TELEROBOTIC CONTROLLER DEVELOPMENT
W. S. OTAGURO, L. O. KESLER (McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.), KEN LAND, and DON RHOADES *In* NASA, Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 1 p 65-71 Nov. 1987
Avail: NTIS HC A18/MF A01 CSCL 09B

To meet NASA's space station's needs and growth, a modular and generic approach to robotic control which provides near-term implementation with low development cost and capability for growth into more autonomous systems was developed. The method uses a vision based robotic controller and compliant hand integrated with the Remote Manipulator System arm on the Orbiter. A description of the hardware and its system integration is presented. Author

N88-16373*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
INTEGRATION OF SYMBOLIC AND ALGORITHMIC HARDWARE AND SOFTWARE FOR THE AUTOMATION OF SPACE STATION SUBSYSTEMS Abstract Only
HUGH GREGG, KATHLEEN HEALEY, EDMUND HACK, and CARLA WONG (National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.) *In* NASA, Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 1 p 81 Nov. 1987
Avail: NTIS HC A18/MF A01 CSCL 09B

Expert systems that require access to data bases, complex simulations and real time instrumentation have both symbolic as well as algorithmic computing needs. These needs could both be met using a general computing workstation running both symbolic and algorithmic code, or separate, specialized computers networked together. The later approach was chosen to implement TEXSYS, the thermal expert system, developed to demonstrate the ability of an expert system to autonomously control the thermal control system of the space station. TEXSYS has been implemented on a Symbolics workstation, and will be linked to a microVAX computer that will control a thermal test bed. Integration options are explored and several possible solutions are presented. Author

N88-16381*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
ARTIFICIAL INTELLIGENCE AND SPACE POWER SYSTEMS AUTOMATION
DAVID J. WEEKS *In its* Third Conference on Artificial Intelligence for Space Applications, Part 1 p 109-113 Nov. 1987
Avail: NTIS HC A18/MF A01 CSCL 09B

Various applications of artificial intelligence to space electrical power systems are discussed. An overview is given of completed, on-going, and planned knowledge-based system activities. These applications include the Nickel-Cadmium Battery Expert System (NICBES) (the expert system interfaced with the Hubble Space Telescope electrical power system test bed); the early work with the Space Station Experiment Scheduler (SSES); the three expert systems under development in the space station advanced development effort in the core module power management and distribution system test bed; planned cooperation of expert systems in the Core Module Power Management and Distribution (CM/PMAD) system breadboard with expert systems for the space station at other research centers; and the intelligent data reduction expert system under development. Author

N88-16388*# Alabama Univ., Huntsville. Center for Applied Optics
GOAL DRIVEN KINEMATIC SIMULATION OF FLEXIBLE ARM ROBOT FOR SPACE STATION MISSIONS Abstract Only
P. JANSSEN and A. CHOUDRY *In* NASA, Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 1 p 151 Nov. 1987
Avail: NTIS HC A18/MF A01 CSCL 09B

Flexible arms offer a great degree of flexibility in maneuvering in the space environment. The problem of transporting an astronaut for extra-vehicular activity using a space station based flexible arm robot was studied. Inverse kinematic solutions of the multilink structure were developed. The technique is goal driven and can support decision making for configuration selection as required for stability and obstacle avoidance. Details of this technique and results are given. Author

N88-16409*# Alabama Univ., Huntsville. Center for Applied Optics
SOLID MODELLING FOR THE MANIPULATIVE ROBOT ARM (POWER) AND ADA/TIVE VISION CONTROL FOR SPACE STATION MISSIONS Abstract Only
V. HARRAND and A. CHOUDRY *In* NASA, Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 1 p 271 Nov. 1987
(Contract NAGW-847)
Avail: NTIS HC A18/MF A01 CSCL 09B

The structure of a flexible arm derived from concatenation of the Stewart-Table-based links were studied. Solid modeling provides not only a realistic simulation, but is also essential for studying vision algorithms. These algorithms could be used for the adaptive control of the arm, using the well-known algorithms such as shape from shading, shape detection, orientation, etc. Details of solid modeling and its relation to vision based adaptive control are discussed. Author

N88-16416*# McDonnell-Douglas Corp., St. Louis, Mo. Artificial Intelligence Group.
PLANNING AND SCHEDULING FOR ROBOTIC ASSEMBLY
BARRY R. FOX. *In* NASA. Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 1 p 309-313 Nov. 1987
Avail: NTIS HC A18/MF A01 CSCL 09B

A system for reasoning about robotic assembly tasks is described. The first element of this system is a facility for itemizing the constraints which determine the admissible orderings over the activities to be sequenced. The second element is a facility which partitions the activities into independent subtasks and produces a set of admissible strategies for each. Finally, the system has facilities for constructing an admissible sequence of activities which is consistent with the given constraints. This can be done off-line, in advance of task execution, or it can be done incrementally, at execution time, according to conditions in the execution environment. The language of temporal constraints and the methods of inference presented in related papers are presented. It is shown how functional and spatial relationships between components impose temporal constraints on the order of assembly and how temporal constraints then imply admissible strategies and feasible sequences. Author

N88-16418*# Alabama Univ., Huntsville. Research Inst.
INTELLIGENT MAN/MACHINE INTERFACES ON THE SPACE STATION
RODNEY S. DAUGHTREY. *In* NASA. Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 1 p 321-325 Nov. 1987
Avail: NTIS HC A18/MF A01 CSCL 09B

Some important topics in the development of good, intelligent, usable man/machine interfaces for the Space Station are discussed. These computer interfaces should adhere strictly to three concepts or doctrines: generality, simplicity, and elegance. The motivation for natural language interfaces and their use and value on the Space Station, both now and in the future, are discussed. Author

N88-16425*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
AN AI APPROACH FOR SCHEDULING SPACE-STATION PAYLOADS AT KENNEDY SPACE CENTER
D. CASTILLO (Harris Corp., Melbourne, Fla.), D. IHRIE, M. MCDANIEL, and R. TILLEY. *In* NASA. Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 1 p 361-370 Nov. 1987
Avail: NTIS HC A18/MF A01 CSCL 09B

The Payload Processing for Space-Station Operations (PHITS) is a prototype modeling tool capable of addressing many Space Station related concerns. The system's object oriented design approach coupled with a powerful user interface provide the user with capabilities to easily define and model many applications. PHITS differs from many artificial intelligence based systems in that it couples scheduling and goal-directed simulation to ensure that on-orbit requirement dates are satisfied. Author

N88-16443*# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
APPLICATIONS OF EXPERT SYSTEMS FOR SATELLITE AUTONOMY
A. CIARLO and P. DONZELLI (LABEN Space Instrumentation and Systems, Milan, Italy). *In* NASA. Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 1 p 453-457 Nov. 1987
Avail: NTIS HC A18/MF A01 CSCL 09B

Some aspects of the on-board application of expert systems in artificial satellites are discussed. The activities of the study, which include the implementation of two prototypes on a dedicated artificial intelligence machine, are described. The general implications of the experience are then discussed. These concern the interrelationship between the expert system and the architecture of the satellite and the expert system's impact on the mission definition phase of the satellite lifecycle. The main obstacles that need to be overcome before operational use of onboard expert systems can take place are discussed. Author

N88-16737*# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Structures and Thermal Control Div.
WHY MECHANISMS ARE CRITICAL TO SPACECRAFT PERFORMANCE
H. M. BRISCOE. *In its* ESA Bulletin No. 10 p 56-59 Aug. 1977
Avail: NTIS HC A05/MF A01

Spacecraft mechanisms used for deployment, momentum wheels, gyroscopes, despin mechanisms, solar array drives, antenna pointing mechanisms, tape recorders, scanning and slewing mechanisms, and spin-up and ejection mechanisms are discussed. The OTS bearing and power transfer assembly, and the GEOS boom system are described. Author (ESA)

N88-17242*# McDonnell Aircraft Co., St. Louis, Mo. Design Engineering-Human Factors.
A HUMAN PERFORMANCE MODELLING APPROACH TO INTELLIGENT DECISION SUPPORT SYSTEMS
MICHAEL S. MOODY and RANDY M. BOYS (Texas Instruments, Inc., Dallas.). *In* NASA. Lyndon B. Johnson Space Center, Houston, Texas. First Annual Workshop on Space Operations Automation and Robotics (SOAR 87) p 261-268 Oct. 1987
Avail: NTIS HC A23/MF A01 CSCL 05H

Manned space operations require that the many automated subsystems of a space platform be controllable by a limited number of personnel. To minimize the interaction required of these operators, artificial intelligence techniques may be applied to embed a human performance model within the automated, or semi-automated, systems, thereby allowing the derivation of operator intent. A similar application has previously been proposed in the domain of fighter piloting, where the demand for pilot intent derivation is primarily a function of limited time and high workload rather than limited operators. The derivation and propagation of pilot intent is presented as it might be applied to some programs. Author

N88-17254*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
EXPERT SYSTEM APPLICATIONS IN SPACECRAFT SUBSYSTEM CONTROLLERS
PAUL F. MARSHALL. *In its* First Annual Workshop on Space Operations Automation and Robotics (SOAR 87) p 349-353 Oct. 1987
Avail: NTIS HC A23/MF A01 CSCL 22B

As NASA progresses into the development phase of the space station, it recognizes the importance and potential payback of high autonomous spacecraft subsystems. Priorities are presented for embedded expert system enhancements to the automatic control systems of the space station thermal, EVA, and life support systems. The primary emphasis is on top level application areas and development concerns for expert systems. Author

N88-17267*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
VISION TECHNOLOGY/ALGORITHMS FOR SPACE ROBOTICS APPLICATIONS
KUMAR KRISHEN and RUI J. P. DEFIGUEIREDO (Rice Univ., Houston, Tex.). *In its* First Annual Workshop on Space Operations Automation and Robotics (SOAR 87) p 441-453 Oct. 1987
Avail: NTIS HC A23/MF A01 CSCL 13I

The thrust of automation and robotics for space applications has been proposed for increased productivity, improved reliability, increased flexibility, higher safety, and for the performance of automating time-consuming tasks, increasing productivity/performance of crew-accomplished tasks, and performing tasks beyond the capability of the crew. This paper provides a review of efforts currently in progress in the area of robotic vision. Both systems and algorithms are discussed. The

evolution of future vision/sensing is projected to include the fusion of multisensors ranging from microwave to optical with multimode capability to include position, attitude, recognition, and motion parameters. The key feature of the overall system design will be small size and weight, fast signal processing, robust algorithms, and accurate parameter determination. These aspects of vision/sensing are also discussed. Author

N88-17269*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

TELEROBOTIC RESEARCH AT NASA LANGLEY RESEARCH CENTER

NANCY E. SLIWA *In* NASA. Lyndon B. Johnson Space Center, Houston, Texas, First Annual Workshop on Space Operations Automation and Robotics (SOAR 87) p 465-469 Oct. 1987

Avail: NTIS HC A23/MF A01 CSCL 13I

An overview of Automation Technology Branch facilities and research is presented. Manipulator research includes dual-arm coordination studies, space manipulator dynamics, end-effector controller development, automatic space structure assembly, and the development of a dual-arm master-slave telerobotic manipulator system. Sensor research includes gravity-compensated force control, real-time monovision techniques, and laser ranging. Artificial intelligence techniques are being explored for supervisory task control, collision avoidance, and connectionist system architectures. A high-fidelity dynamic simulation of robotic systems, ROBSIM, is being supported and extended. Cooperative efforts with Oak Ridge National Laboratory have verified the ability of teleoperators to perform complex structural assembly tasks, and have resulted in the definition of a new dual-arm master-slave telerobotic manipulator. A bibliography of research results and a list of technical contacts are included. Author

N88-17270*# Rockwell International Corp., Downey, Calif. Space Station Systems Div.

MANIPULATOR ARM DESIGN FOR THE EXTRAVEHICULAR TELEOPERATOR ASSIST ROBOT (ETAR): APPLICATIONS ON THE SPACE STATION

MARGARET M. CLARKE, CHARLES J. DIVONA, and WILLIAM M. THOMPSON (NSA Electro-Mechanidcal Systems Div., Breta, Calif.) *In* NASA. Lyndon B. Johnson Space Center, Houston, Texas, First Annual Workshop on Space Operations Automation and Robotics (SOAR 87) p 471-475 Oct. 1987

(Contract NAS8-36629)

Avail: NTIS HC A23/MF A01 CSCL 13I

The preliminary conceptual design of a new teleoperator robot manipulator system for space station maintenance missions has been completed. The system consists of a unique pair of arms that is part of a master-slave, force-reflecting servomanipulator. This design allows greater dexterity and greater volume coverage than that available in current designs and concepts. The teleoperator manipulator is specifically designed for space applications and is a valuable extension of the current state-of-the-art earthbound manipulators marketed today. The manipulator and its potential application on the space station are described. Author

N88-17272*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

TELEROBOTIC TRUSS ASSEMBLY

PHILIP L. SHERIDAN *In its* First Annual Workshop on Space Operations Automation and Robotics (SOAR 87) p 487-491 Oct. 1987

Avail: NTIS HC A23/MF A01 CSCL 13I

The ACCESS truss was telerobotically assembled in order to gain experience with robotic assembly of hardware designed for astronaut extravehicular (EVA) assembly. Tight alignment constraints of the ACCESS hardware made telerobotic assembly difficult. A wider alignment envelope and a compliant end effector would have reduced the problem. The manipulator had no linear motion capability, but many of the assembly operations required straight line motion. The manipulator was attached to a motion table in order to provide the X, Y, and Z translations needed. A programmable robot with linear translation capability would have eliminated the need for the motion table and streamlined the assembly. Poor depth perception was a major problem. Shaded paint schemes and alignment lines were helpful in reducing this problem. The four cameras used worked well for only some operations. It was not possible to identify camera locations that worked well for all assembly steps. More cameras or movable cameras would have simplified some operations. The audio feedback system was useful. Author

N88-17273*# Rockwell International Corp., Downey, Calif. Space Station Systems Div.

CREW INTERFACE WITH A TELEROBOTIC CONTROL STATION

EVA MOK *In* NASA. Lyndon B. Johnson Space Center, Houston, Texas, First Annual Workshop on Space Operations Automation and Robotics (SOAR 87) p 493-496 Oct. 1987

Avail: NTIS HC A23/MF A01 CSCL 05H

A method for apportioning crew-telerobot tasks has been derived to facilitate the design of a crew-friendly telerobot control station. To identify the most appropriate state-of-the-art hardware for the control station, task apportionment must first be conducted to identify if an astronaut or a telerobot is best to execute the task and which displays and controls are required for monitoring and performance. Basic steps that comprise the task analysis process are: (1) identify space station tasks; (2) define tasks; (3) define task performance criteria and perform task apportionment; (4) verify task apportionment; (5) generate control station requirements; (6) develop design concepts to meet requirements; and (7) test and verify design concepts. Author

N88-17274*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

TELEROBOT FOR SPACE STATION

LYLE M. JENKINS *In its* First Annual Workshop on Space Operations Automation and Robotics (SOAR 87) p 497-499 Oct. 1987

Avail: NTIS HC A23/MF A01 CSCL 13I

The Flight Telerobotic Servicer (FTS), a multiple arm dexterous manipulation system, will aid in the assembly, maintenance, and servicing of the space station. Fundamental ideas and basic conceptual designs for a shuttle-based telerobot system have been produced. Recent space station studies provide additional concepts that should aid in the accomplishment of mission requirements. Currently, the FTS is in contractual source selection for a Phase B preliminary design. At the same time, design requirements are being developed through a series of robotic assessment tasks being performed at NASA and commercial installations. A number of the requirements for remote operation on the space station, necessary to supplement extravehicular activity (EVA), will be met by the FTS. Finally, technology developed for telerobotics will advance the state of the art of remote operating systems, enhance operator productivity, and prove instrumental in the evolution of an adaptive, intelligent autonomous robot. Author

N88-17279*# Mitre Corp., Houston, Tex.

TASK-LEVEL ROBOT PROGRAMMING: INTEGRAL PART OF EVOLUTION FROM TELEOPERATION TO AUTONOMY

JAMES C. REYNOLDS *In* NASA. Lyndon B. Johnson Space Center, Houston, Texas, First Annual Workshop on Space Operations Automation and Robotics (SOAR 87) p 533-540 Oct. 1987

Avail: NTIS HC A23/MF A01 CSCL 09B

An explanation is presented of task-level robot programming and of how it differs from the usual interpretation of task planning for robotics. Most importantly, it is argued that the physical and mathematical basis of task-level robot programming provides inherently greater reliability than efforts to apply better known concepts from artificial intelligence (AI) to autonomous robotics. Finally, an architecture is presented that allows the integration of task-level robot programming within an evolutionary, redundant, and multi-modal framework that spans teleoperation to autonomy. Author

N88-17999*# National Bureau of Standards, Gaithersburg, Md. Robot Systems Div.
NASA/NBS (NATIONAL AERONAUTICS AND SPACE ADMINISTRATION/NATIONAL BUREAU OF STANDARDS) STANDARD REFERENCE MODEL FOR TELEROBOT CONTROL SYSTEM ARCHITECTURE (NASREM) Final Report
J. S. ALBUS, H. G. MCCAIN, and R. LUMIA Jul. 1987 94 p Sponsored by NASA
(PB88-124773; NBS/TN-1235; NAS 1.15:89726; NASA-TM-89726) Avail: NTIS HC A05/MF A01; also Avail: SOD $4.50 as SN003-003-02819-3 CSCL 13I

The NASA Standard Reference Model (NASREM) Architecture for the Space Station Telerobot Control System is described. It defines the functional requirements and high level specifications of the control system for the NASA Space Station document for the functional specification, and a guideline for the development of the control system architecture, of the IOC Flight Telerobot Servicer. The NASREM telerobot control system architecture defines a set of standard modules and interfaces which facilitates software design, development, validation, and test, and makes possible the integration of telerobotics software from a wide variety of sources. Standard interfaces also provide the software hooks necessary to incrementally upgrade future Flight Telerobot Systems as new capabilities develop in computer science, robotics, and autonomous system control. GRA

N88-19491# Tecnospazio S.p.A., Milan (Italy).
IN-ORBIT AUTOMATIC ASSEMBLY OF RETICULAR STRUCTURES
P. G. MAGNANI and G. COLOMBINA *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 47-52 Nov. 1987
Avail: NTIS HC A21/MF A01

Automatic in-orbit assembly of reticular structures by a general-purpose robot assembler is proposed. The robot can crawl on the structure and act on its main elements (rods, corner blocks) by means of a suitable manipulative system. Evaluations show that a two arm system (nine degrees of freedom each arm) is adequate. The robot can operate under sequencer control or under human teleoperation. The level of sensoriality is high, including vision capability, laser range system, proximity sensor, and force/torque and strain/stress sensors. The considerations presented are for assembling a repetitive automatizable process as for an industrial application. Further analyses are necessary to take into account all the aspects related to space environment as well the future trend for large space structures. ESA

N88-19493# Erno Raumfahrttechnik G.m.b.H., Bremen (West Germany).
AUTOMATIC IN-ORBIT PAYLOAD DEPLOYMENT MECHANISMS, LOGISTIC OPERATIONS AND TRANSPORT VEHICLE DESIGN COMPATIBILITIES
S. GRAUL *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 63-70 Nov. 1987
Avail: NTIS HC A21/MF A01

Three in-orbit deployment and loading mechanisms integrated into an advanced space transport system called LART are presented. The design parameters are the reduction of operation costs for payload loading and deployment and the reduction of the complexity of the mechanism. The influence of both parameters leads to a telescope mechanism as well as to two advanced long-term concepts, which are a tethered end effector and an autonomous operating payload container. For the telescope mechanism structural and dynamical aspects are outlined. ESA

N88-19502# Fokker B.V., Amsterdam (Netherlands).
THE ESA/FOKKER SERVICE END-EFFECTOR SUBSYSTEM. A ROBOTIC/MAN-COMPATIBLE SERVICING APPROACH
A. C. M. VANSWIETEN and R. H. BENTALL (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 145-157 Nov. 1987
Avail: NTIS HC A21/MF A01

The requirements, design, and operational performance of an end effector are presented. Design objectives, trade-offs, breadboard models, tests, and developments are covered. Design characteristics are: robotic/man compatible grapple fixture; grappling performance compatible with Hermes Robot Arm and Service Manipulator system; versatile application of tools; power and data bus connection for coupling with intelligent tools; torque and force sensing capabilities for compliant operations; and status checking and decision making inside the end-effector-subsystem. A range of possible tools which would comprise the basic servicing capabilities is described. ESA

N88-19504# LABEN Space Instrumentation and Systems, Milan (Italy).
ROBOTIC INTELLIGENCE ISSUES FOR SPACE MANIPULATOR MONITORING, CONTROL PROGRAMMING
P. DONZELLI, R. CORTINOVIS, and S. MASSARI (Centro Studi ed Applicazioni in Tecnologie Avanzate, Bari, Italy) *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 165-173 Nov. 1987
Avail: NTIS HC A21/MF A01

Software requirements and artificial intelligence techniques for robotics for the Space Station Service Manipulator System (SMS) were studied. Intelligence requirements to be applied on the SMS, a framework of distributed knowledge based systems for SMS monitoring, programming, and control, and a plan of research for the practical experimentation of such architecture are presented. ESA

N88-19505# Technische Hochschule, Darmstadt (West Germany).
ON A KNOWLEDGE BASED ASSISTED SYSTEM FOR HIGHLY AUTONOMOUS CONTROL OF EXPERIMENT-MANIPULATORS IN THE MAN-TENDED FREE FLYER
G. KEGEL, A. ABDULWAHAB, and R. BRUDER *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 175-183 Nov. 1987 Sponsored by BMFT
Avail: NTIS HC A21/MF A01

A knowledge based control and sensor-feedback hierarchy concept which performs global task-oriented manipulation sequences filled with specific knowledge and initialized by the general ground station command is presented. It is intended for the control systems for in-orbit experiment and maintenance manipulators, where highly autonomous performance of multisensor controlled task sequences is used as an alternative to direct teleoperation. The theoretical knowledge base concept, similar to the Winston-Horn frame structure, is elaborated into implementable data structures. The knowledge represented in rules and physical data used by algorithms for planning a subcommand sequence consisting of single steps of various sensor feedback configurations is discussed. An implemented robot-control interface library and the sensor-equipped end effector for verification of expected performances is described. ESA

N88-19507# Karlsruhe Univ. (West Germany).
MOBILE ROBOT ACTIVITY MODEL FOR AUTONOMOUS FREE FLYING PLATFORMS
U. REMBOLD, R. DILLMANN, A. KELLNER, and J. EITELJOERGE (Erno Raumfahrttechnik G.m.b.H., Bremen, West Germany) *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 191-202 Nov. 1987 Sponsored by Deutsche Forschungsgeimeinschaft
Avail: NTIS HC A21/MF A01

The use of artificial intelligence (AI) techniques for the control problem of free flying autonomous platforms is discussed. For rendezvous, docking and manipulation operation between target system and chaser appropriate integrated control systems consisting of planning components, execution control components and supervision components are required. An experimental terrestrial mobile autonomous robot system capable of travelling, docking, and manipulation with two manipulator arms is presented.

This system is under development to evaluate the efficiency of AI-tools and their integration into complex systems to perform complex tasks or missions autonomously in an unstructured environment. ESA

N88-19509# Technische Hochschule, Darmstadt (West Germany).
REMOTE MANIPULATION IN ORBITAL CONSTRUCTION, SERVICING AND REPAIR MISSIONS: IS ONE ARM ENOUGH? A COMPARATIVE EVALUATION OF THE PERFORMANCE FEATURES OF ROBOTS WITH ONE OR MORE ARMS
H. BRUHM *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 217-225 Nov. 1987
Avail: NTIS HC A21/MF A01

Qualitative and quantitative performance features which are expected to make the difference between single and multiarm systems for orbital robots are reviewed. Methods for comparative evaluation of single and multiarm systems with respect to their maximum force/torque capability, payload positioning accuracy, repeatability, and stiffness are presented. The capabilities of multiarm systems are highlighted by the analysis of two tasks. The use of single-arm systems is not recommended. ESA

N88-19511# Erno Raumfahrttechnik G.m.b.H., Bremen (West Germany).
TREATMENT OF UNFORESEEN SITUATIONS BY ONLINE KNOWLEDGE-BASED DIAGNOSTIC SYSTEMS
A. KELLNER *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 235-244 Nov. 1987
Avail: NTIS HC A21/MF A01

The use of knowledge based systems (KBS) in space in sophisticated online fault management systems, having the ability to react appropriately to unforeseen anomalies is discussed. The idea appears feasible, since KBS does not depend on a premeditation of all possible anomalies, but on knowledge about the functional structure of the monitored system. However, this ability cannot be realized if the encoded knowledge is based on two-valued logic, as is the case with many KBS. Instead, it is shown that a knowledge representation based on multivalued logic is required. As a practical illustration, the behavior of an expert system for fault diagnosis in the cooling loop of EURECA is described. It is shown that multivalued logic allows for nonconclusive knowledge and knowledge redundancy, which facilitates fault tolerance of KBS in the sense of an insensitiveness to failures in the sensory system or faults in the knowledge base due to ill-coding or irradiation of computer memory. ESA

N88-19518# MATRA Espace, Toulouse (France).
PROMISING CONCEPTS FOR GROUND-TO-ORBIT EXPERIMENT TELEOPERATION
PH. LEBOUAR and C. LOEILLET *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 301-308 Nov. 1987
Avail: NTIS HC A21/MF A01

System and user requirements for ground based control of spaceborne experiments are reviewed, and a telescience concept is described. The communication network is based on two separate high data rate links between data relay satellites (DRS) and users in low Earth orbit. It allows a two way link between ground users and DRS without ground retransmission. The onboard data management system is essentially the same as for standard payload control, but with additional functions such as accepting time tagged commands and command validation without user control on the ground. The impact of the telescience concept on the Columbus User Operations Center and Payload Operations Control Center is assessed. A concept validation phase is outlined. ESA

N88-19527# MATRA Espace, Paris-Velizy (France).
UTILIZATION OF ROBOTICS AND TELEOPERATION FOR FUTURE IN-ORBIT OPERATIONS
TH. BLAIS, J. L. LACOMBE, and P. WETZEL *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 377-383 Nov. 1987
Avail: NTIS HC A21/MF A01

The main in-orbit elements and operations required by the future in-orbit infrastructure are reviewed. Man's role and location with respect to the operations areas is a major design element for space teleoperation and robotics systems. It is shown that robotics/teleoperation and man have to be considered as complementary, enabling large operational autonomy of the robotics system when man performs on-ground or remote supervision (e.g., from a space station). This is applicable for assembly (external robotics) and payload operations (internal robotics). Efficient and safe work share between the external manipulator arm and the man in pressurized area (on the same space system) may be an alternative to extravehicular activity (EVA) or preferably the nominal way to perform operations which cannot be fully completed by EVA only (large load transfer). The telemanipulator arm provides both the astronaut transfer capability (with loads and tools) and a firm support at work site (open cherry picker), increasing the effectiveness of EVA (less astronaut fatigue, shorter transfer time). A man in the pressurized area ensures supervision. ESA

N88-19529# Sener S.A., Madrid (Spain).
ROBOTICS SERVICING EXPERIMENT
C. COMPOSTIZO, M. FUENTES, D. KASSING, and M. VANWINNENDAEL (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 391-398 Nov. 1987
Avail: NTIS HC A21/MF A01

The Robotics Servicing Experiment (ROSE) which is part of a complete robotic servicing demonstration program to provide the future European in orbit infrastructure with a well qualified robotic servicing system is introduced. The objectives of ROSE include: (1) verification of subsystems and performances of the Robotic System which cannot be completed on ground; (2) Validation of robotic servicing operations and techniques (task planning, teleoperation procedures, and associated techniques such as capture and berthing); (3) Validation by comparison of ground and in orbit test results of tools, facilities, and methods used within the on ground verification program of the robotic system. (Simulation models, test facilities, overall verification program philosophy); and (4) Validation of the complete robotic system including associated equipment and interfaces by its operation under realistic in orbit environmental conditions. The system is considered validated after the updating and validation of the ground verification program which covers a higher number of operational cases and conditions. ESA

N88-19536*# TRW Space Technology Labs., Redondo Beach, Calif.
TECHNOLOGY REQUIREMENTS FOR TELEROBOTIC SATELLITE SERVICING IN SPACE
HANS F. MEISSINGER *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 459-467 Nov. 1987
(Contract NAS8-35031)
Avail: NTIS HC A21/MF A01 CSCL 05H

Telerobotic servicer technology requirements were identified for typical on-orbit servicing operations, including: automation requirements and automated system utilization in typical servicing missions; key automation technologies used for servicing; evolution concepts; technology development timetable; and servicing technology drivers. Teleoperation, robotics, and artificial intelligence are needed in the servicing missions investigated. Analysis shows that teleoperation will be used more widely than fully robotic systems, at least during the early space station years because of the diversity and unpredictability of many servicing tasks which call for the human operator's skills, resourcefulness, and decision-making ability. There will be heavy dependence on a sophisticated, flexible, readily accessible, high-speed and

high-capacity data management system which can provide the expert system support required in diagnosing, troubleshooting, decision making, task scheduling, and mission planning. ESA

N88-19537# British Aerospace Public Ltd. Co., Stevenage (England). Space and Communications Div.
A TELEOPERATED MANIPULATOR SYSTEM CONCEPT FOR UNMANNED PLATFORMS
J. MURDOCH and J. S. SHEPPARD *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 469-474 Nov. 1987
Avail: NTIS HC A21/MF A01

A Platform Manipulator System (PMS) concept is proposed to provide, as a primary function, a means of exchanging payload and utility orbit replacement units (ORU) between an unmanned platform and a docked logistics vehicle without the need for man in orbit. The concept is principally directed towards Columbus Polar Platform in order to avoid the requirement to de-orbit for a servicing operation, but is also applicable to the external servicing of the resource module of the Man-Tended Free Flyer. Features of the proposed system include teleoperation from ground, a dual berthing ORU exchange function, a limited rotational transportation capability of the manipulator base, and a bi-arm end effector concept. ESA

N88-19538# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
MAN-TENDED OPTIONS FOR EUROPEAN SPACE ROBOTICS
R. H. BENTALL and D. KASSING *In its* Proceedings of the 1st European In-Orbit Operations Technology Symposium p 475-483 Nov. 1987
Avail: NTIS HC A21/MF A01

Options and applications for robotics in European man-tended and autonomous operations in space are discussed, and future options for European robotics are identified. Man-tended robotics operations for internal and external servicing (including the Hermes robot arm) are reviewed. A technology demonstration program is proposed. ESA

11

MATERIALS

Includes mechanical properties of materials, and descriptions and analyses of different structural materials, films, coatings, bonding materials and descriptions of the effects of natural and induced space environments.

A88-13202
CARBOFLEX - A NEW GENERAL PURPOSE PITCH-BASED CARBON FIBER
JOHN W. NEWMAN (Ashland Petroleum Co., KY) IN: Advanced materials technology '87; Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr. 6-9, 1987. Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 938-944. refs

A unique petroleum pitch feedstock has been used in a proprietary process to manufacture pitch-based Carboflex carbon fibers suitable for asbestos substitution. The fiber possesses thermal conductivity, chemical inertness, and the strength of steel at 1/5 the weight. Carboflex fibers have asbestos-substitution applications in brakes, gaskets, flooring, and furnace insulation; high technology applications encompass X-ray tables, space platform structures, medical prostheses, storage batteries, chemical warfare filters, and surface-activated filter chemical systems. O.C.

A88-13239* Boeing Aerospace Co., Seattle, Wash.
PROTECTIVE COATINGS FOR COMPOSITE TUBES IN SPACE APPLICATIONS
HARRY W. DURSCH and CARL L. HENDRICKS (Boeing Aerospace Co., Seattle, WA) IN: Advanced materials technology '87; Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr. 6-9, 1987. Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 1569-1580. Previously announced in STAR as N87-18669.
(Contract NAS1-16854)

Protective coatings for graphite/epoxy (Gr/Ep) tubular structures for a manned Space Station truss structure were evaluated. The success of the composite tube truss structure depends on its stability to long-term exposure to the low earth orbit (LEO) environment, with particular emphasis placed on atomic oxygen. Concepts for protectively coating Gr/Ep tubes include use of inorganic coated metal foils and electroplating. These coatings were applied to Gr/Ep tubes and then subjected to simulated LEO environment to evaluate survivability of coatings and coated tubes. Evaluation included: atomic oxygen resistance, changes in optical properties and adhesion, abrasion resistance, surface preparation required, coating uniformity, and formation of microcracks in the Gr/Ep tubes caused by thermal cycling. Program results demonstrated that both phosphoric and chromic acid anodized Al foil provided excellent adhesion to Gr/Ep tubes and exhibited stable optical properties when subjected to simulated LEO environment. The SiO2/Al coatings sputtered onto Al foils also resulted in an excellent protective coating. Electroplated Ni exhibited unacceptable adhesion loss to Gr/Ep tubes during atomic oxygen exposure. Author

A88-16006#
THE USE OF ADVANCED MATERIALS IN SPACE STRUCTURE APPLICATIONS
D. C. G. EATON and E. J. SLACHMUYLDERS (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 15 p. refs
(IAF PAPER 87-305)

The increasing use of composite materials is discussed as well as the integrity control of primary structures fabricated from composite materials (manned flight). New composite materials required to retain their properties up to at least 200 C are expected to be used extensively in the Hermes spaceplane. To ensure a safe structure, consideration should be given to mixed metal-composite load carrying structures, aeroelastic behavior, acoustic fatigue, crashworthiness, and hypersonic velocity meteoroid/debris impact (among many other factors). K.K.

A88-20701
LOOKING AHEAD FOR MATERIALS AND PROCESSES; PROCEEDINGS OF THE EIGHTH SAMPE (EUROPEAN CHAPTER) INTERNATIONAL CONFERENCE, LA BAULE, FRANCE, MAY 19-21, 1987
JACQUES DE BOSSU, ED. (Brochier, S.A., Neuilly-sur-Seine, France), GUY BRIENS, ED. (Aerospatiale, Suresnes, France), and PIERRE LISSAC, ED. (Hexcel-Genin, S.A., Lyons, France) Conference sponsored by SAMPE, Aerospatiale, Brochier, S.A., et al. Amsterdam, Elsevier (Materials Science Monographs. Volume 41), 1987, 508 p. For individual items see A88-20702 to A88-20729.

The present conference on emerging advanced materials and processes encompasses topics in low temperature cure polymers, aeronautical applications, adhesives, naval and maritime applications, spaceborne materials, composite behavior, ceramics, and thermoplastic polymers. Attention is given to glass-matrix composites' manufacture and performance, aluminum- and steel-matrix composites, novel materials used in the Rafale fighter, UV processing of prepregs, cost-effective thermoplastic composite processing, lightning protection for aircraft and space vehicles, the aging effects of sea water on materials, GFRP for OTEC plant cold water intakes, atomic oxygen effects in low orbit, and the properties of the Nextel 440 ceramic fiber. O.C.

A88-21554
STRENGTHENING GRAPHITE-EPOXY COMPOSITES
Aerospace Engineering (ISSN 0736-2536), vol. 7, 1987, p. 60-62.

Intercalated graphite, in fibrous form, increases the mechanical strength of composites by enhancing the adhesion between fibers and polymer matrices; the interlaminar shear strength of brominated carbon fiber/epoxy composites is accordingly 18 percent greater than its pristine-fiber counterpart, although brominated fiber mechanical properties are themselves unaffected by bromination. Attention is presently given to the case of bromination-intercalated graphite flakes reinforcing a furfuryl alcohol thermosetting resin matrix; tensile strength is noted to be increased by 167 percent, and flexural stength by 118 percent, over the unbrominated test samples. O.C.

A88-21618
OPTICAL FIBER WAVEGUIDES FOR SPACECRAFT APPLICATIONS
E. J. FRIEBELE, K. L. DORSEY, and M. E. GINGERICH (U.S. Navy, Naval Research Laboratory, Washington, DC) IN: Fiber optics in adverse environments III; Proceedings of the Meeting, Cambridge, MA, Sept. 25, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 98-103. refs

Optical fiber waveguides may be subjected to unique adverse environments onboard spacecraft, including wide temperature ranges and low dose rate radiation exposures. Since fiber reliability is essential, an accelerated life test has been designed to simulate deployment on the Space Station. The initial induced losses following exposure at -150 C are much lower in the fibers with pure silica cores than in those with doped silica cores. Good long-term recovery is evident at this low temperature in fibers which do not contain P, provided light is being transmitted in the waveguide, since photobleaching is the dominant recovery mechanism in both types of fiber at -150 C. Except for the P-doped waveguides, the worst-case incremental losses are extrapolated to be less than 10 dB/km for a 10-year, 1 rad/day exposure at -150 C with a -20 dBm signal in the fiber. Author

A88-22320#
A SIMPLE MODEL FOR THE INITIAL PHASE OF A WATER PLASMA CLOUD ABOUT A LARGE STRUCTURE IN SPACE
D. E. HASTINGS, N. A. GATSONIS, and T. MOGSTAD (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(Contract F19628-86-K-0018)
(AIAA PAPER 88-0430)

Large structures in the ionosphere will outgas or eject neutral water and perturb the ambient neutral environment. This water can undergo charge exchange with the ambient oxygen ions and form a water plasma cloud. Additionally, water dumps or thruster firings can create a water plasma cloud. A simple model for the evolution of a water plasma cloud about a large space structure is obtained. It is shown that if the electron density around a large space structure is substantially enhanced above the ambient density then the plasma cloud will move away from the structure. As the cloud moves away it will become unstable and will eventually break up into filaments. A true steady state will exist only if the total electron density is unperturbed from the ambient density. When the water density is taken to be consistent with Shuttle based observations the cloud is found to slowly drift away on a timescale of many tens of milliseconds. This time is consistent with the Shuttle observations. Author

A88-26965
MATERIALS SELECTION AS RELATED TO CONTAMINATION OF SPACECRAFT CRITICAL SURFACES
CHARLES E. VEST, ROBERT M. BUCHA, and MICHAEL J. LENKEVICH (Johns Hopkins University, Laurel, MD) SAMPE Quarterly (ISSN 0036-0821), vol. 19, Jan. 1988, p. 29-35. refs

The contamination of spacecraft scientific instrumentation, thermal control surfaces, and other critical components, may be substantially due to improper selection of construction materials as well as inadequate attention to cleanliness during fabrication, assembly, testing, etc. An account is presently given of materials selection and contamination control plan-related procedures. Attention is given to the sources of contaminating films on sensors, the classification of spacecraft conditions, the management of a simulated VUV instrument's decontamination, and the removal of contaminating films while in orbit. O.C.

A88-29585
HIGH TEMPERATURE RESISTANT COMPLIANT MODIFIED EPOXIES
S. L. OLDHAM and W. E. ELIAS (Hughes Aircraft Co., El Segundo, CA) SAMPE Journal (ISSN 0091-1062), vol. 24, Mar.-Apr. 1988, p. 9-11, 165.

A family of compliant modified epoxies has been synthesized for use as adhesives, coatings, and encapsulants; the base resins exhibited low viscosities, glass transition temperatures, and outgassing characteristics with high peel temperatures and decomposition temperatures. Attention is presently given to baseline material data obtained for one of these modified resins, HRG-3, which is a viable, solvent-free, toughened epoxy system for applications in which thermal stability, repairability, abrasion and moisture resistance, and low outgassing, are all important, as in spacecraft structures subjected to LEO particulate bombardment. O.C.

A88-31390*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
RESPONSE OF COMPOSITE MATERIALS TO THE SPACE STATION ORBIT ENVIRONMENT
S. S. TOMPKINS, D. E. BOWLES, W. S. SLEMP, and L. A. TEICHMAN (NASA, Langley Research Center, Hampton, VA) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 108-116. refs
(AIAA PAPER 88-2476)

The rationale for selecting composite materials with an anodized aluminum foil coating for the Space Station is presented. Data on the effects of the space service environment on these materials are given. Results are also presented on the effect of optical properties of an aluminum/aluminum oxide coating on the thermal balance of the cylindrical structural members. The resistance of this coating to solar ultraviolet degradation is discussed. C.D.

A88-31404
OUTGASSING OF SPACECRAFT COMPOSITES
ROBERT D. KARAM (Fairchild Space Co., Germantown, MD) IN: Composite structures 4; Proceedings of the Fourth International Conference, Paisley, Scotland, July 27-29, 1987. Volume 1. London and New York, Elsevier Applied Science, 1987, p. 1.45-1.58. refs

Diffusion and outgassing of contaminants in spacecraft composite structures are evaluated. The generalized mass and heat transfer equations are simplified for application to thin platforms, and a mathematical model is constructed for predicting outgassing rates as a function of orbital temperatures. It is found that small changes in temperature can have a major influence on the time needed for a structure to reach a specified level of residual contamination. Numerical examples are presented to illustrate application of the theory, and recommendations are given for testing and for monitoring orbital temperatures. Author

N88-10117*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
OUTGASSING DATA FOR SELECTING SPACECRAFT MATERIALS
WILLIAM A. CAMPBELL, JR. and RICHARD S. MARRIOTT Aug. 1987 323 p Revised
(NASA-RP-1124; REPT-87B0347; NAS 1.61:1124) Avail: NTIS HC A14/MF A01 CSCL 11D

Outgassing data, derived from tests at 398 K (125 C) for 24 hours in vacuum as per ASTM E 595-77, have been compiled for numerous materials for spacecraft use. The data presented are

the total mass loss (TML) and the collected volatile condensable materials (CVCM). The various materials are listed by likely usage and alphabetically. Author

N88-10203# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
PRELIMINARY STUDY OF A CONTAINERLESS PROCESSING FACILITY FOR COLUMBUS, EXECUTIVE SUMMARY
R. BEHRLE Paris, France ESA Jan. 1987 11 p
(Contract ESA-6508/85-F-FL(SC))
(ESA-ITT-AO/1-1,834/85F; ESA-CR(P)-2387; ETN-87-90520)
Avail: NTIS HC A03/MF A01

The compatibility between spaceborne heating and levitation concepts and the requirements of experiments on containerless processing with metals and glasses, measurement of material properties, crystal growth, critical point phenomena, combustion of single drops, and fluid sciences was studied. The feasibility of aerodynamic levitation up to 2200 C is questionable, even under microgravity. The development of a high temperature ZrO_2-heater for space application is favored. High technological challenge is posed by two color pyrometric measurements. Operational problems are outlined. ESA

N88-10206# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
PREPHASE A STUDY OF A CRYSTALLIZATION LABORATORY FOR COLUMBUS, EXECUTIVE SUMMARY
R. BEHRLE Paris, France ESA Jan. 1987 13 p
(Contract ESA-6616/85-F-HEW(SC))
(ESA-ITT/AO/1-1866/85F; ESA-CR(P)-2399; ETN-87-90534)
Avail: NTIS HC A03/MF A01

Crystal growth techniques for organic and inorganic materials were reviewed. Experiment requirements were established. Design concepts for selected facilities were studied, emphasizing modular concepts. Diagnostics, stimuli, and accommodation aspects were investigated. ESA

N88-10847*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
HIGH INTENSITY 5 EV O-ATOM EXPOSURE FACILITY FOR MATERIAL DEGRADATION STUDIES
J. B. CROSS, L. H. SPANGLER, M. A. HOFFBAUER, F. A. ARCHULETA, LUBERT LEGER, JAMES VISENTINE, and DON E. HUNTON (Air Force Geophysics Lab., Hanscom AFB, Mass.) *In* NASA- Goddard Space Flight Center, Greenbelt, Md. Fourteenth Space Simulation Conference: Testing for a Permanent Presence in Space p 209-226 1986
Avail: NTIS HC A19/MF A01 CSCL 07D

An atomic oxygen exposure facility was developed for studies of material degradation. The goal of these studies is to provide design criteria and information for the manufacture of long life (20 to 30 years) construction materials for use in low Earth orbit. The studies that are being undertaken will provide: (1) absolute reaction cross sections for the engineering design problems, (2) formulations of reaction mechanisms for use in the selection of suitable existing materials and the design of new more resistant ones, and (3) the calibration of flight hardware (mass spectrometers, etc.) in order to directly relate experiments performed in low Earth orbit to ground based investigations. The facility consists of a CW laser sustained discharge source of O-atoms, an atomic beam formation and diagnostics system, a spinning rotor viscometer, and provision for using the system for calibration of actual flight instruments. Author

N88-10896*# Case Western Reserve Univ., Cleveland, Ohio. Dept. of Physics.
DEGRADATION MECHANISMS OF MATERIALS FOR LARGE SPACE SYSTEMS IN LOW EARTH ORBIT Final Report, 6 Oct. 1982 - 5 Jan. 1985
WILLIAM L. GORDON and R. W. HOFFMAN Nov. 1987 32 p
(Contract NAG3-352)
(NASA-CR-181472; NAS 1.26:181472) Avail: NTIS HC A03/MF A01 CSCL 11D

Degradation was explored of various materials used in aerospace vehicles after severe loss of polymeric material coatings (Kapton) was observed on an early shuttle flight in low Earth orbit. Since atomic oxygen is the major component of the atmosphere at 300 km, and the shuttle's orbital velocity produced relative motion corresponding to approx. 5 eV of oxygen energy, it was natural to attribute much of this degradation to oxygen interaction. This assumption was tested using large volume vacuum systems and ion beam sources, in an exploratory effort to produce atomic oxygen of the appropriate energy, and to observe mass loss from various samples as well as optical radiation. Several investigations were initiated and the results of these investigations are presented in four papers. These papers are summarized. They are entitled: (1) The Space Shuttle Glow; (2) Laboratory Degradation of Kapton in a Low Energy Oxygen Ion Beam; (3) The Energy Dependence and Surface Morphology of Kapton Degradation Under Atomic Oxygen Bombardment; and (4) Surface Analysis of STS 8 Samples. Author

N88-11715 Centre d'Etude Spatiale des Rayonnements, Toulouse (France). Dept. d'Etudes et de Recherches en Technologie Spatiale.
SPACECRAFT SURFACE EXPOSURE TO ATOMIC OXYGEN IN LOW EARTH ORBIT
ALAIN PAILLOUS *In* CNES, Space Environment Technology p 353-375 Apr. 1987 In FRENCH; ENGLISH summary
Avail: CEPADUES-Editions, Toulouse, France

Flight experiments in the shuttle payload bay showing that interaction of oxygen atoms with surfaces can cause significant erosion of materials and components in low Earth orbits are discussed. Neutral atmospheric composition and its variations are described. Reaction efficiencies of various spacecraft surface materials are given. The fluences to which surfaces in typical orbits are exposed are estimated. The problems of the simulation techniques to be used in laboratory are considered. ESA

N88-12529*# McDonnell-Douglas Astronautics Co., Houston, Tex.
SPACECRAFT MATERIAL FLAMMABILITY TESTING AND CONFIGURATIONS
PAUL W. LEDOUX *In* NASA, Lewis Research Center, Spacecraft Fire Safety p 95-98 1987
Avail: NTIS HC A07/MF A01 CSCL 11D

Material and configuration testing for the Space Shuttle is mainly at 30 percent oxygen concentration at 70 kPa (10.2 psia). This is the worst case atmosphere during a mission and occurs 10 hours prior to extravehicular activity. The pressure is reduced from the nominal 101 kPa (14.7 psia) and the oxygen concentration is increased to 30 percent for medical reasons to prevent the bends during the extravehicular activity. NASA has tested many materials at 23.8, 25.9 and 30 percent oxygen levels for the Shuttle program. Data is given to show how flammability of material is affected by percentage of oxygen for those materials that would be considered for spacecraft applications. Author

N88-12546# United Technologies Research Center, East Hartford, Conn.
CARBON FIBER REINFORCED GLASS MATRIX COMPOSITES FOR SPACE BASED APPLICATIONS Annual Report, 1 Jul. 1986 - 30 Jun. 1987
WILLIAM K. TREDWAY and KARL M. PREWO 31 Aug. 1987 89 p
(Contract N00014-85-C-0332)
(AD-A184355; UTRC/R87-917470-1) Avail: NTIS HC A05/MF A01 CSCL 11D

High elastic modulus (HMU) carbon fibers were combined with several different glass and glass ceramic matrix compositions. The importance of the fiber matrix interface in the control of composite performance was central to the investigation and was evaluated by correlating mechanical properties with microstructural and microchemical analysis of the interfacial region. Lithium aluminosilicate (LAS) glass-ceramic matrix composites were developed with tensile stress-strain behavior comparable to

borosilicate glass matrix composites. Carbon fiber reinforced glass matrix composites of 0/90 deg orientation were found to be relatively notch insensitive. Lowering of the processing temperature of 7740/HMU composites was found to affect composite mechanical performance through matrix consolidation effects. Interfacial reactions between the carbon fiber and various matrix additives (nb205, mo03) were found to have a profound effect on composite mechanical behavior via formation of an interfacial carbide layer which increased fiber-matrix interfacial bond strength. GRA

N88-15077*# Boeing Aerospace Co., Seattle, Wash.
CHROMIC ACID ANODIZING OF ALUMINUM FOIL Final Report
H. DURSCH Jan. 1988 40 p
(Contract NAS1-18224)
(NASA-CR-178417; NAS 1.26:178417) Avail: NTIS HC A03/MF A01 CSCL 11C

The success of the Space Station graphite/epoxy truss structure depends on its ability to endure long-term exposure to the LEO environment, primarily the effects of atomic oxygen and the temperture cycling resulting from the 94 minute orbit. This report describes the development and evaluation of chromic acid anodized (CAA) aluminum foil as protective coatings for these composite tubes. Included are: development of solar absorptance and thermal emittance properties required of Al foil and development of CAA parameters to achieve these optical properties; developing techniques to CAA 25 ft lengths of Al foil; developing bonding processes for wrapping the Al foil to graphite/epoxy tubes; and atomic oxygen testing of the CAA Al foil. Two specifications were developed and are included in the report: Chromic Acid Anodizing of Aluminum Foil Process Specification and Bonding of Anodized Aluminum Foil to Graphite/Epoxy Tubes. Results show that CAA Al foil provides and excellent protective and thermal control coating for the Space Station truss structure. Author

N88-15082*# College of William and Mary, Williamsburg, Va. Dept. of Chemistry.
SPACE ENVIRONMENTAL EFFECTS ON POLYMERIC MATERIALS Semiannual Progress Report, 1 Jun. - 30 Nov. 1987
RICHARD L. KIEFER and ROBERT A. ORWOLL 15 Feb. 1988 6 p
(Contract NAG1-678)
(NASA-CR-182418; NAS 1.26:182418) Avail: NTIS HC A02/MF A01 CSCL 11B

Polymer-matrix composites have considerable potential for use in the construction of orbiting structures such as the space station and space antennas because of their light weight, high strength, and low thermal expansion. However, they can suffer surface erosion by interaction with atomic oxygen in low-Earth orbit and degradation and/or embrittlement by electrons and ultraviolet radiation especially in geosynchronous orbit. Thus, a study of the effect of these environmental hazards on polymeric materials is an important step in the assessment of such materials for future use in space. Author

N88-16824# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).
INTEGRITY CONTROL OF CARBON FIBER REINFORCED PLASTICS (CFRP) STRUCTURAL ELEMENTS. CONCLUSION WITH RESPECT TO THE CONTROL METHODOLOGY OF CFRP PRIMARY STRUCTURES IN MANNED SPACE FLIGHT AND THE IMPLICATIONS TO THE DESIGN, ANALYSIS AND TESTING OF CFRP STRUCTURAL ELEMENTS, EXECUTIVE SUMMARY Supplement to Final Report
WERNER H. PAUL Paris, France ESA 1985 87 p
(Contract ESA-4442/80-NL-AK(SC))
(MBB-TN-RB517-014/85; ESA-CR(P)-2517; ETN-88-91709)
Avail: NTIS HC A05/MF A01

A three fold control logic related to development, manufacturing, and operation of safety relevant structures is established in order to exclude catastrophic failures of CFRP-elements due to the existence of global degradation or local defects. Verification of integrity control requirements during development; design concepts for critical structural items; global deviations and local defects; stress evaluation; material properties; the impact of macroscopic defects on the static capability; the degradation of capabilities with increasing operational life; nondestructive inspection of CFRP elements; and a simplified design procedure are discussed. ESA

N88-16879*# College of William and Mary, Williamsburg, Va. Dept. of Chemistry.
SPACE ENVIRONMENTAL EFFECTS ON POLYMERIC MATERIALS Final Technical Report, 1 May 1986 - 31 May 1987
RICHARD L. KIEFER and ROBERT A. ORWOLL 1987 31 p
(Contract NAG1-678)
(NASA-CR-182454; NAS 1.26:182454) Avail: NTIS HC A03/MF A01 CSCL 11B

Polymeric materials that may be exposed on spacecraft to the hostile environment beyond Earth's atmosphere were subjected to atomic oxygen, electron bombardment, and ultraviolet radiation in terrestrial experiments. Evidence is presented for the utility of an inexpensive asher for determining the relative susceptibility of organic polymers to atomic oxygen. Kapton, Ultem, P1700 polysulfone, and m-CBB/BIS-A (a specially formulated polymer prepared at NASA Langley) all eroded at high rates, just as was observed in shuttle experiments. Films of Ultem, P1700 polysulfone, and m-CBB/BIS-A were irradiated with 85 keV electrons. The UV/VIS absorbance of Ultem was found to decay with time after irradiation, indicating free radical decay. The tensile properties of Ultem began to change only after it had been exposed to 100 Mrads. The effects of dose rate, temperature, and simultaneous vs. sequential electron and UV irradiation were also studied. Author

N88-18734*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OXIDATION AND PROTECTION OF FIBERGLASS-EPOXY COMPOSITE MASTS FOR PHOTOVOLTAIC ARRAYS IN THE LOW EARTH ORBITAL ENVIRONMENT
SHARON K. RUTLEDGE, PHILLIP E. PAULSEN, JOYCE A. BRADY (Cleveland State Univ., Ohio.), and MICHAEL L. CIANCONE 1988 12 p Presented at the Spring Meeting of the Materials Research Society, Reno, Nev., 5-9 Apr. 1988
(NASA-TM-100839; E-4027; NAS 1.15:100839) Avail: NTIS HC A03/MF A01 CSCL 11B

Fiberglass-epoxy composites are considered for use as structural members for the mast of the space station solar array panel. The low Earth orbital environment in which space station is to operate is composed mainly of atomic oxygen, which has been shown to cause erosion of many organic materials and some metals. Ground based testing in a plasma asher was performed to determine the extent of degradation of fiberglass-epoxy composites when exposed to a simulated atomic oxygen environment. During exposure, the epoxy at the surface of the composite was oxidized, exposing individual glass fibers which could easily be removed. Several methods of protecting the composite were evaluated in an atomic oxygen environment and with thermal cycling and flexing. The protection techniques evaluated to date include an aluminum braid covering, an indium-tin eutectic and a silicone based paint. The open aluminum braid offered little protection while the CV-1144 coating offered some initial protection against atomic oxygen, but appears to develop cracks which accelerate degradation when flexed. Coatings such as the In-Sn eutectic may provide adequate protection by containing the glass fibers even though mass loss still occurs. Author

12

INFORMATION AND DATA MANAGEMENT

Includes descriptions, requirements, and trade studies of different information and data system hardware and software, languages, architecture, processing and storage requirements for managing and monitoring of different systems and subsystems.

A88-12755* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACEBORNE OPTICAL DISK CONTROLLER DEVELOPMENT
THOMAS A. SHULL and BRUCE A. CONWAY (NASA, Langley Research Center, Hampton, VA) IN: Optical mass data storage II; Proceedings of the Meeting, San Diego, CA, Aug. 18-22, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 347-352.

The current status and potential applications of an optical-disk buffer (ODB) memory system being developed by an interagency consortium including NASA and the USAF are reviewed. The design goals for the ODB include usable capacity 1 Tb, maximum data rate 1.6 Gb/s, read error rate less than 10 to the -12th, time to initial access less than 100 ms, and unlimited read/write cycles. Present efforts focus on a brassboard ODB which employs 12 14-inch magnetooptic disks and 24 nine-diode read/write heads. A typical space application of an optical disk mass memory system (ODMMS) is discussed: as communications buffer, temporary storage, and/or multiuser I/O buffer for data management on the Space Station Earth Observing System. Environmental, operational, system-architecture, and functional-separation factors; critical design issues; and standardization questions for spaceborne ODMMSs are examined in detail. T.K.

A88-15282* National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
SPACE STATION GROUND DATA MANAGEMENT SYSTEM
JAN HEUSER and WILLIAM SLOAN (NASA, Kennedy Space Center, Cocoa Beach, FL) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 8 p.

KSC is planning a Space Station Ground Data Management System (GDMS) for support of functional interface verification, integration and test of Space Station modules and elements. This computer system, planned for initial operational support in 1992, currently is entering a definition and prototyping stage. This paper provides an overview of the GDMS system concept. It synopsizes system functional capabilities, and discusses software and hardware architectural approaches currently under evaluation. It identifies programmatic constraints and their influence upon the concept, as well as specific technical issues planned for study or evaluation via prototyping. Author

A88-15303* National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
THE USE OF TRANSPUTERS IN PROCESSING TELEMETRY DATA
HUGO M. DELGADO, JR. (NASA, Kennedy Space Center, Cocoa Beach, FL) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 10 p.

Parallelism will be an essential ingredient of high performance systems of the future. The Inmos transputer is a high performance single-chip computer whose architecture facilitates the construction of parallel processing systems. Occam is a high level language developed for use with the Inmos transputer. This paper describes a project to evaluate the feasibility of using the transputer to implement real time processing of telemetry data. Author

A88-15851*# National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION INFORMATION SYSTEM - CONCEPTS AND INTERNATIONAL ISSUES
R. B. WILLIAMS, DAVID PRUETT, and DANA L. HALL (NASA, Space Station Program Office, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 10 p. refs
(IAF PAPER 87-76)

The Space Station Information System (SSIS) is outlined in terms of its functions and probable physical facilities. The SSIS includes flight element systems as well as existing and planned institutional systems such as the NASA Communications System, the Tracking and Data Relay Satellite System, and the data and communications networks of the international partners. The SSIS strives to provide both a 'user friendly' environment and a software environment which will allow for software transportability and interoperability across the SSIS. International considerations are discussed as well as project management, software commonality, data communications standards, data security, documentation commonality, transaction management, data flow cross support, and key technologies. K.K.

A88-15863*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SCIENCE ON THE SPACE STATION: THE OPPORTUNITY AND THE CHALLENGE - A NASA VIEW
MICHAEL DEVIRIAN, JAMES R. WEISS (California Institute of Technology, Jet Propulsion Laboratory, Pasadena; NASA, Office of Space Science and Applications, Washington, DC), and ERWIN SCHMERLING (NASA, Office of Space Science and Applications, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 8 p.
(IAF PAPER 87-92)

The Science and Applications Information System (SAIS) which will provide users with remote, interactive, and iterative access from their home locations to the many information system services is introduced. Such aspects as transaction management, standard format data units, and the use of intelligent data management systems are discussed. It is concluded that new and innovative approaches to information management must be developed so that the full potential of the Space Station can be realized with respect to the demands of the entire science community. K.K.

A88-19869
DAMMING THE DATA STREAM FROM SPACE
DAVID SLOGGET Space (ISSN 0267-954X), vol. 3, Nov.-Dec. 1987, p. 30-34.

The Polar Platform of the NASA Space Station will be a highly complex data collection system with transmission rates placing large burdens on the ground segment in terms of data processing, dissemination, and archiving. The candidate areas for onboard instrument processing are data compression, bulk correction, image interpretation, and supporting instrumentation. The major task of onboard processing should be transmission bandwidth reduction which can be achieved most efficiently via data compression. K.K.

A88-21087* McDonnell-Douglas Astronautics Co., Huntsville, Ala.
A COMPUTER AIDED ENGINEERING TOOL FOR ECLS SYSTEMS
MICHAL E. BANGHAM (McDonnell Douglas Astronautics Co., Huntsville, AL) and JAMES L. REUTER (NASA, Marshall Space Flight Center, Huntsville, AL) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 11 p.
(SAE PAPER 871423)

The Computer-Aided Systems Engineering and Analysis tool used by NASA for environmental control and life support system design studies is capable of simulating atmospheric revitalization systems, water recovery and management systems, and single-phase active thermal control systems. The designer/analysis interface used is graphics-based, and allows the designer to build a model by constructing a schematic of the system under consideration. Data management functions are performed, and the

program is translated into a format that is compatible with the solution routines. O.C.

A88-21253
A PACKETISED REMOTE VISUAL ACCESS DATA SYSTEM FOR SPACE STATION INTERACTIVE PAYLOAD OPERATIONS
R. P. CARVELL (Imperial College of Science and Technology, London, England) Acta Astronautica (ISSN 0094-5765), vol. 15, Sept. 1987, p. 651-659. refs

Potential users of the pressurized Columbus elements, (the Attached Pressurized Module and the Man-Tended Free Flyer), were consulted in order to establish the requirements necessary to achieve effective and efficient remote interactive payload operations. These are briefly described and clearly indicate that the key to such operations is a versatile remote visual access (video) system which is well-tuned to the requirements of the users in both the on-board and ground segments. A packetized remote visual access data system is proposed which accommodates these requirements and offers a very flexible operational environment. It incorporates a scheme for optimizing users' remote visual access to their experiments. Methods of implementing the necessary multiplexing and compression aspects of the system are discussed. A scheme for centralized on-board monitoring, which is complicated by the wide range of video sources required by the users, is outlined and aspects of the ground segment, in particular the problem of link delays, are considered. Author

A88-21257
A DATA BASE APPROACH TOWARDS COLUMBUS PAYLOAD ACCOMODATION
J. FROMM and G. GOELZ (DFVLR, Cologne, Federal Republic of Germany) Acta Astronautica (ISSN 0094-5765), vol. 15, Sept. 1987, p. 731-737.

The design characteristics of the Columbus payload data base (CPDB) prototype version installed at ESA/ESTEC and DFVLR are discussed, with special consideration given to the data design, user interface, communication within the user community, and integrability. Attention is also given to the analysis of the data requirements and the functional requirements. First experiences with the CPDB showed that it is a valuable tool in the process of payload definition for the elements of the Columbus program. The built-in growth potential of the system and its well-defined interfaces allow for its integration into a net of international information systems, which will be necessary in Phase C/D of the Columbus program. I.S.

A88-21650* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
COMPUTING ARCHITECTURE FOR TELEROBOTS IN EARTH ORBIT
A. K. BEJCZY, R. S. DOTSON, and Z. SZAKALY (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 172-177.

Based on generic operational and computational requirements associated with the control of telerobots in earth orbit, a multibus-based distributed but integrated computing architecture is proposed. An experimental system of that kind under development at the Jet Propulsion Laboratory (JPL) is briefly described. It uses Intel Multibus I at both control station and remote robot (telerobot) computing nodes. An essential element within each multibus is a Unified (or Universal) Computer Control Subsystem (UCCS) for telerobot and control station motor components. The two multibus-based computing nodes can be linked by parallel or high speed serial links for real-time data transmission and for closing the real-time bilateral (force-reflecting) control loop between telerobot and control station. The experimental system is briefly commented, followed by a brief discussion of future development plans and possibilities. Author

A88-21654
IMPLEMENTATION OF EXPERT SYSTEM TECHNOLOGY ON THE SPACE STATION
ARDELL NEASE and RICHARD FULWIDER, II (Rockwell International Corp., Space Station Systems Div., Downey, CA) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 212-217.

The problem of implementing expert systems and the man-machine interfaces which make them effective on the Space Station is discussed. The process of identifying and selecting functions to which expert systems can be applied is addressed. The hosting environment for the Space Station expert systems is examined. C.D.

A88-22011*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
ENVIRONET DATABASE ON VIBROACOUSTICS
FRANK J. ON (NASA, Goddard Space Flight Center, Greenbelt, MD) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 6 p.
(AIAA PAPER 88-0010A)

This paper discusses the current ENVIRONET computer based information management system on vibroacoustic (random vibration and acoustic) environments for Space Transportation System payloads. The application of the data base to support cost effective payload development programs is described. Included also is a discussion of the current status of the data base and future plans for expanding and improving the data base to include additional payload carriers, Space Station, and expendable launch vehicle payloads. Author

A88-22082#
NETWORK MANAGEMENT FOR THE SPACE STATION INFORMATION SYSTEM
JOHN V. PIETRAS and MICHAEL A. ALLEN (Mitre Corp., Greenbelt, MD) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p. refs
(AIAA PAPER 88-0118)

NASA's Space Station Information System (SSIS) communications networks will furnish computer-to-computer data, audio, and video traffic services, as well as traditional spacecraft command and telemetry data flows. The SSIS will accomplish this by means of a combination of NASA institutional, public, and international networks, using several protocol suites. The 'network management' task of integrating, controlling, and monitoring this concentration of networks is presently discussed with a view to the formulation of a candidate network management architecture. O.C.

A88-22329#
AUTOMATED SPACE STATION PROCEDURE EXECUTION
CHRISTINE M. KELLY (Mitre Corp., Houston, TX) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 5 p. refs
(AIAA PAPER 88-0443)

The Operations Management System (OMS) of the Space Station base is the system of procedures and processes which constitute an integrated operations environment for the base. That portion of OMS which is responsible for implementing onboard automation is referred to as the OMA. In this paper, a prototype is described which demonstrates a possible implementation of one OMA function: the coordination of systems, elements, payloads, and crew operations in execution of the short-term plan. C.D.

A88-23081#
EVOLUTION OF DATA MANAGEMENT SYSTEMS FROM SPACELAB TO COLUMBUS
GUENTHER BRANDT and HANS-J. POSPIESZCZYK (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) AIAA and NASA, Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22-24, 1987, Paper.

8 p.
(MBB-UR-E-968-87)

The evolution of data processing concepts is reviewed with reference to the experience gained from the development of Spacelab and its utilization, the ongoing development of the Eureca system, and the present design and specification phase of Columbus. It is noted that the development of special architectures, interfaces, and protocols should be avoided and performed only if existing commercially available solutions cannot be used. The architecture design should provide for efficient accommodation of technology progress. The need for powerful simulations not only for early testing but also for in-depth and efficient assessment and monitoring of the data processing system performance is emphasized. V.L.

A88-26211#
ACCESS CONTROL FOR A SAFETY CRITICAL DISTRIBUTED SYSTEM INTERFACE SET
SUE LEGRAND (SofTech, Houston, TX) IN: Applying technology to systems; Aerospace Computer Security Conference, 3rd, Orlando, FL, Dec. 7-11, 1987, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 108-113. refs
(AIAA PAPER 87-3083)

The Space Station Program (SSP) requires a system that has many safety critical resources that must be kept secure. The Space Station Information System (SSIS) is defined as the integrated set of space and ground data and information networks which provide required data and information services to the flight crew, ground operations personnel, and the customer community. It includes as its elements not only flight element systems such as the onboard data management, communications and tracking systems; but also existing and planned institutional systems such as the NASA Communications Systems (NASCOM), the Tracking and Data Relay Satellite System (TDRSS) and the data and communications networks of the scientific and industrial users and the international partners. The SSIS (1986) is conceived to support the full range of users in all operations of their subsystems or experiments that involve data handling, processing and/or storage regardless of where physically each user is located. Author

A88-29820*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NASA SPACEBORNE OPTICAL DISK RECORDER DEVELOPMENT
THOMAS A. SHULL, REGINALD M. HOLLOWAY, and BRUCE A. CONWAY (NASA, Langley Research Center, Hampton, VA) SPIE, Optical Storage Technology and Application Conference, Los Angeles, CA, Jan. 10-15, 1988, Paper. 8 p.

Spaceflight application of a high performance (high rate, high capacity) erasable optical disk recorder is discussed. An expandable modular system concept is proposed consisting of multiple drive modules and a modular system controller. A drive contains two 14-inch magneto-optic disks and four electro-optic heads, each containing a nine-diode solid state laser array (eight data tracks, one pilot track). The performance goals of the drive module are 20 gigabyte capacity, 300 megabit per second transfer rate, 10x(Exp-10) corrected BER, and 100 millisecond access time. The system goals are 120 gigabyte capacity at up to 1.8 gigabits per second rate, concurrent I/O, varying data rates, reconfigurable architecture, and 2 to 5 year operating life in orbit. The system environment and operational scenarios are presented. Author

A88-30189
SIMPLE ANALYSIS OF SPACE STATION DOWNLINKS
J. BRANEGAN British Interplanetary Society, Journal (Soviet Astronautics) (ISSN 0007-084X), vol. 41, March 1988, p. 135-139.

Information is presented which will allow an ordinary person with no specialized radio or language skills to monitor what cosmonauts are doing inside a Space Station. The times and places that cosmonauts can be overheard and the monitoring procedure are briefly addressed. Typical incidents that occurred from 1985 to 1987 and that had sound clues on the downlink are described, including an ice-cold rescue, a medical emergency, a station-to-station transfer, and extravehicular activities. The categories of signals and sounds which can be heard on a typical Space Station downlink are given and discussed. C.D.

N88-11402*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
REPORT FROM THE MPP WORKING GROUP TO THE NASA ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE AND APPLICATIONS Technical Memorandum Report, 1 Oct. 1985 - 30 Sep. 1986
JAMES R. FISCHER, CHESTER GROSCH, MICHAEL MCANULTY, JOHN ODONNELL, and OWEN STOREY (Stanford Univ., Calif.) Nov. 1987 64 p
(NASA-TM-87819; REPT-87B0265; NAS 1.15:87819) Avail: NTIS HC A04/MF A01 CSCL 09B

NASA's Office of Space Science and Applications (OSSA) gave a select group of scientists the opportunity to test and implement their computational algorithms on the Massively Parallel Processor (MPP) located at Goddard Space Flight Center, beginning in late 1985. One year later, the Working Group presented its report, which addressed the following: algorithms, programming languages, architecture, programming environments, the way theory relates, and performance measured. The findings point to a number of demonstrated computational techniques for which the MPP architecture is ideally suited. For example, besides executing much faster on the MPP than on conventional computers, systolic VLSI simulation (where distances are short), lattice simulation, neural network simulation, and image problems were found to be easier to program on the MPP's architecture than on a CYBER 205 or even a VAX. The report also makes technical recommendations covering all aspects of MPP use, and recommendations concerning the future of the MPP and machines based on similar architectures, expansion of the Working Group, and study of the role of future parallel processors for space station, EOS, and the Great Observatories era. Author

N88-13375# RADEX, Inc., Carlisle, Mass.
ANALYSIS OF GEOPHYSICAL DATA BASES AND MODELS FOR SPACECRAFT INTERACTIONS Final Technical Report, Aug. 1983 - Oct. 1986
J. N. BASS, N. A. BONITO, K. G. COTTRELL, R. J. ECKHARDT, and W. J. MCNEIL 31 Oct. 1986 276 p
(Contract F19628-83-C-0105)
(AD-A184809; AFGL-TR-86-0221) Avail: NTIS HC A13/MF A01 CSCL 04A

This contract supported on-going as well as planned research into environments and spacecraft interactions in near space. The major projects are summarized. Models and geophysical data bases were investigated for spacecraft charging, shuttle contamination, electrostatic particle pushing codes, beam-plasma interaction in emitting probes, and magnetospheric dynamics. Adiabatic invariance of trapped particles, fluxgate magnetometer simulation and falling sphere accelerometers. In support of the CRRES project, a data management plan has been provided, and a graphics capability developed for the SPAN network. Software development was involved in all phases, using CYBER, VAX and RIDGE computers. GRA

N88-13378# Consiglio Nazionale delle Ricerche, Frascati (Italy). Ist. di Fisica dello Spazio Interplanetario.
RESEARCH ON ELECTRODYNAMIC TETHER EFFECTS (RETE) EXPERIMENT ELECTRICAL GROUND SUPPORT EQUIPMENT (EGSE)
U. GUIDONI and M. MAGGI Jan. 1987 26 p
(IFSI-87-2; ETN-88-91289) Avail: NTIS HC A03/MF A01

The hardware, software, and test procedures of the Electrical Ground Support Equipment (EGSE) to simulate the interfaces of the Orbiter with the tethered satellite and to perform functional tests and data display are described. The main requirement is the possibility to utilize the EGSE, with slight changes, during the subsequent phases of experiment integration and during the Shuttle mission. The EGSE is needed to integrate three experiment

subsystems: an ac package to measure three orthogonal components of the electrical field (from 170 Hz to 12 MHz) and 2 orthogonal components of the magnetic field (from 170 Hz to 450 KHz); a dc package which performs Langmuir probe measurements to determine the local plasma characteristic, including the local plasma potential; and a data processing unit for data acquisition and control of interfaces with satellite telemetry. ESA

N88-13860# Saab-Space A.B., Linkoeping (Sweden).
STUDY OF FAULT TOLERANT TECHNIQUES FOR SATELLITE DATA HANDLING Final Report, Dec. 1986
J. HANJE, J. TORIN, T. ELIASSON, M. SVENINGSSON, J. CONTET, J. P. SOTTA, P. H. LEBOUAR, D. PERARNAUD, P. VLIMANT, D. POWELL (Laboratoire d'Automatique et de Ses Applications Spatiales, Toulouse, France) et al. Paris, France ESA 26 Jan. 1987 149 p Prepared in cooperation with Chalmers Univ. of Technology, Goeteborg (Sweden)
(Contract ESTEC-6074/84-NL-PB)
(FTT/REP/0001/SAAB; ESA-CR(P)-2427; ETN-88-90886) Avail: NTIS HC A07/MF A01

Orbital transfer vehicle and deep space probe missions were analyzed to identify the requirements of a target Data Handling Subsystem (DHS). Fault tolerant techniques were assessed to catalog the fault tolerant features especially applicable for space use. Transient faults due to heavy ion induced single event upsets were emphasized, because of their very large influence on space applications. Candidate solutions were analyzed and synthesized into a design architecture of the Target DHS. The fault tolerant features of the Target DHS are found to reside in a central on board computer. Two DHS architectures were established, one for each mission. The different requirements of dependability led to different architectures of the fault tolerant computers. ESA

N88-14864*# Auburn Univ., Ala. Dept. of Chemistry
DEVELOPMENT OF A GRAPHICAL DISPLAY ON THE DMS TEST BED Final Report
ROBERT A. DONNELLY *In* NASA. Lyndon B. Johnson Space Center, Houston, Tex. NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 1 9 p Nov. 1987
Avail: NTIS HC A15/MF A01 CSCL 09B

The DMS test bed is a model of a data network aboard space station. Users of the network share data relevant to the functional status of various systems aboard the station. Users may inquire the status of myriad sensors, obtaining reading of station subsystem status in real time via the Data Acquisition and Distribution Service. A graphical display of the status of a simulation of the Environmental Control and Life Support System was developed. Two broad issues were addressed: (1) flexible, extensible software design; and (2) the impact of utilizing standard processors, languages, and graphics packages implementing the software design concept. The experience gained with DEC hardware, the DEC implementation of the GKS graphics standard, and with Ada is summarized. Author

N88-14870*# New Mexico State Univ., Las Cruces. Dept. of Electrical and Computer Engineering.
HIGH DATA RATE MODEM SIMULATION FOR THE SPACE STATION MULTIPLE-ACCESS COMMUNICATIONS SYSTEM Final Report
STEPHEN HORAN *In* NASA. Lyndon B. Johnson Space Center, Houston, Tex. NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 1 19 p Nov. 1987
Avail: NTIS HC A15/MF A01 CSCL 17B

The communications system for the space station will require a space based multiple access component to provide communications between the space based program elements and the station. A study was undertaken to investigate two of the concerns of this multiple access system, namely, the issues related to the frequency spectrum utilization and the possibilities for higher order (than QPSK) modulation schemes for use in possible modulators and demodulators (modems). As a result of the investigation, many key questions about the frequency spectrum utilization were raised. At this point, frequency spectrum utilization is seen as an area requiring further work. Simulations were conducted using a computer aided communications system design package to provide a straw man modem structure to be used for both QPSK and 8-PSK channels. Author

N88-14884*# Houston Univ., Tex. Dept. of Industrial Engineering.
SPACE STATION SOFTWARE RELIABILITY ANALYSIS BASED ON FAILURES OBSERVED DURING TESTING AT THE MULTISYSTEM INTEGRATION FACILITY Final Report
TAK CHAI TAMAYO *In* NASA. Lyndon B. Johnson Space Center, Houston, Tex. NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 2 20 p Nov. 1987
Avail: NTIS HC A15/MF A01 CSCL 09B

Quality of software not only is vital to the successful operation of the space station, it is also an important factor in establishing testing requirements, time needed for software verification and integration as well as launching schedules for the space station. Defense of management decisions can be greatly strengthened by combining engineering judgments with statistical analysis. Unlike hardware, software has the characteristics of no wearout and costly redundancies, thus making traditional statistical analysis not suitable in evaluating reliability of software. A statistical model was developed to provide a representation of the number as well as types of failures occur during software testing and verification. From this model, quantitative measure of software reliability based on failure history during testing are derived. Criteria to terminate testing based on reliability objectives and methods to estimate the expected number of fixings required are also presented. Author

N88-15004# LABEN Space Instrumentation and Systems, Milan (Italy).
EXPERT SYSTEM STUDY FOR SPACECRAFT MANAGEMENT Final Report
P. DONZELLI, B. ANKERMOELLER, B. SOERENSEN, and R. KATZENBEISSER (Dornier-Werke G.m.b.H., Friedrichshafen, West Germany) Feb. 1987 110 p
(Contract ESA-6029/84)
(TL-2699-ISS-1; ESA-CR(P)-2445; ETN-88-91142) Avail: NTIS HC A06/MF A01

The feasibility with state of the art technology of an on-board expert system for management of an autonomous spacecraft was assessed. Requirements for the design, development and test of the expert system were specified. Fault management functions were selected and knowledge about them was detailed for power and on-board data handling. The definition of such domain knowledge was supported by a knowledge specification formalism proposed by the knowledge engineers to the domain experts for the preliminary acquisition of all the information considered useful and necessary for the creation of the knowledge base. The development environment, and approaches for the testing, evaluation and validation of the prototype fault management system were studied. The impact of the use of on-board expert systems on ground/spacecraft communication protocols and on board complexity was assessed. ESA

N88-15395*# Boeing Co., Huntsville, Ala. AI Center.
FMEASSIST: A KNOWLEDGE-BASED APPROACH TO FAILURE MODES AND EFFECTS ANALYSIS
JAMES R. CARNES and DANNIE E. CUTTS *In* NASA. Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 1 p 187-191 Nov. 1987
Avail: NTIS HC A18/MF A01 CSCL 09B

A Failure Modes and Effects Analysis workstation (FMEAssist) was designed for use during the development of the space station. It assists engineers in the complex task of tracking failures and their effects on the system. Engineers experience increased productivity through reduced clerical loads, reduced data

inconsistency, and significantly reduced analysis time. System developments benefit from a more thorough analysis than was available using previous methods. Author

N88-16404*# McDonnell-Douglas Corp., St. Louis, Mo. Research Labs.
KNOWLEDGE-BASED SIMULATION
P. A. NEWMAN *In* NASA. Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 1 p 249-253 Nov. 1987
Avail: NTIS HC A18/MF A01 CSCL 09B

An architecture for a knowledge-based simulator is described. The task of scheduling represents an area in which such a tool might be applied. More specifically, scheduling for crew and ground support activities for the shuttle and space station would benefit from the application of knowledge-based simulation. The knowledge-based simulator would allow the crew and support personnel to schedule and reschedule activities in a timely and flexible manner in order to examine and test possible plans. Author

N88-16423*# Boeing Aerospace Co., Huntsville, Ala.
FOUNDATION: TRANSFORMING DATA BASES INTO KNOWLEDGE BASES
R. B. PURVES, JAMES R. CARNES, and DANNIE E. CUTTS (Boeing Co., Huntsville, Ala.) *In* NASA. Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 1 p 353-357 Nov. 1987
Avail: NTIS HC A18/MF A01 CSCL 05B

One approach to transforming information stored in relational data bases into knowledge based representations and back again is described. This system, called Foundation, allows knowledge bases to take advantage of vast amounts of pre-existing data. A benefit of this approach is inspection, and even population, of data bases through an intelligent knowledge-based front-end. Author

N88-16427*# Computer Sciences Corp., Beltsville, Md. System Sciences Div.
THE RESOURCE ENVELOPE AS A BASIS FOR SPACE STATION MANAGEMENT SYSTEM SCHEDULING
JOY BUSH and ANNA CRITCHFIELD *In* NASA. Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 1 p 377-381 Nov. 1987
(Contract NAS5-28620)
Avail: NTIS HC A18/MF A01 CSCL 09B

The Platform Management System (PMS) Resource Envelope Scheduling System (PRESS) expert system prototype developed for space station scheduling is described. The purpose of developing the prototype was too investigate the resource envelope concept in a practical scheduling application, using a commercially available expert system shell. PRESS is being developed on an IBM PC/AT using Teknowledge, Inc.'s M.1 expert system shell. Author

N88-16577*# National Academy of Sciences - National Research Council, Washington, D. C.
CRITICAL ISSUES IN NASA INFORMATION SYSTEMS Final Report
Jun. 1987 68 p
(Contract NASW-4124)
(NASA-CR-182380; NAS 1.26:182380; PB88-101027) Avail: NTIS HC A04/MF A01 CSCL 05B

The National Aeronautics and Space Administration has developed a globally-distributed complex of earth resources data bases since LANDSAT 1 was launched in 1972. NASA envisages considerable growth in the number, extent, and complexity of such data bases, due to the improvements expected in its remote sensing data rates, and the increasingly multidisciplinary nature of its scientific investigations. Work already has begun on information systems to support multidisciplinary research activities based on data acquired by the space station complex and other space-based and terrestrial sources. In response to a request from NASA's former Associate Administrator for Space Science and Applications, the National Research Council convened a committee in June 1985 to identify the critical issues involving information systems support to space science and applications. The committee has suggested that OSSA address four major information systems issues; centralization of management functions, interoperability of user involvement in the planning and implementation of its programs, and technology. GRA

N88-17258*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
TDAS: THE THERMAL EXPERT SYSTEM (TEXSYS) DATA ACQUISITION SYSTEM
EDMUND C. HACK (Lockheed Engineering and Management Services Co., Inc., Houston, Tex.) and KATHLEEN J. HEALEY *In its* First Annual Workshop on Space Operations Automation and Robotics (SOAR 87) p 375-382 Oct. 1987
Avail: NTIS HC A23/MF A01 CSCL 09B

As part of the NASA Systems Autonomy Demonstration Project, a thermal expert system (TEXSYS) is being developed. TEXSYS combines a fast real time control system, a sophisticated human interface for the user and several distinct artificial intelligence techniques in one system. TEXSYS is to provide real time control, operations advice and fault detection, isolation and recovery capabilities for the space station Thermal Test Bed (TTB). TEXSYS will be integrated with the TTB and act as an intelligent assistant to thermal engineers conducting TTB tests and experiments. The results are presented from connecting the real time controller to the knowledge based system thereby creating an integrated system. Special attention will be paid to the problem of filtering and interpreting the raw, real time data and placing the important values into the knowledge base of the expert system. Author

N88-19884*# Taylor and Associates, Inc., Wrightwood, Calif.
SPACE STATION ARCHITECTURAL ELEMENTS MODEL STUDY. SPACE STATION HUMAN FACTORS RESEARCH REVIEW
THOMAS C. TAYLOR, EYOUB KHAN, JOHN SPENCER, CARLOS ROCHA, and ETHAN WILSON CLIFFTON (Clifton, Ethan Wilson, San Francisco, Calif.) *In* NASA. Ames Research Center, Space Station Human Factors Research Review. Volume 3: Space Station Habitability and Function: Architectural Research p 117-135 Oct. 1987
Avail: NTIS HC A10/MF A01 CSCL 05H

Presentation visuals and an extended abstract represent a study to explore and analyze the interaction of major utilities distribution, generic workstation, and spatial composition of the SPACEHAB space station module. Issues addressed include packing densities vs. circulation, efficiency of packing vs. standardization, flexibility vs. diversity, and composition of interior volume as space for living vs. residual negative volume. The result of the study is expected to be a series of observations and preliminary evaluation criteria which focus on the productive living environment for a module in orbit. J.P.B.

13

ACCOMMODATIONS

Includes descriptions of simulations, analyses, trade studies, and requirements for safe efficient procedures, facilities, and support equipment on the ground and in space for processing, servicing, maintenance, reliability, commonality, verification and checkout of cargo and equipment.

A88-15206
A MODEL FOR ENVELOPING SPACE STATION LOGISTICS REQUIREMENTS
K. M. SEISER and R. E. GIUNTINI (Wyle Laboratories, El Segundo,

CA) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 9 p.

Since the inception of the Space Station Customer Logistics Study, it became apparent that a modeling process was needed to provide insight into the many sensitivities and relationships which exist among the numerous variables which impact Space Station customer accommodations and logistics support requirements with regard to their associated design requirements. This paper addresses the current design and operations of the Space Station, with emphasis on the Manufacturing and Technology Laboratory (MTL) which is the primary focus of the study and the model. Typical experiments planned for the MTL are addressed as well as their on-orbit operational and logistical requirements. A detailed description of the model developed under the study along with some of its many applications for scoping Space Station logistics requirements is presented. Author

A88-15287
SPACEHAB - A MANNED SPACE STATION TESTBED
ROBERT CITRON (Spacehab, Inc., Seattle, WA) and THOMAS C. TAYLOR (Spacehab, Inc., Washington, DC) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 40 p. refs

The efforts of a commercial space venture in creating a manned space station testbed based in the Shuttle are described. It is creating a near-term pressurized equipment test bed module and developmental scenario for Space Station with private financing. The Spacehab Module research capability simulating the Space Station interior environment will be available 3-5 yrs before IOC. The Spacehab Module has created a low-cost, lower-risk development scenario for the commercial customer at Space Station through a Space Station Simulation Module. The Spacehab Module is to be fabricated for later attachment to the Space Station, to provide an evolutionary research capability in orbit, to evolve as the industry and station hardware emerge, and to provide cost-effective service through a private space commercialization organization. Author

A88-15864#
SCIENCE PLANS AND REQUIREMENTS FOR THE U.S./INTERNATIONAL SPACE STATION
PETER M. BANKS (Stanford University, CA) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 3 p.
(IAF PAPER 87-93)

Of principal importance to the U.S./International Space Station (US/ISS) is the opportunity to exploit the microgravity environment for studies related to materials science and technology, fundamental physics and chemistry in a low-g environment, and the conduct of a variety of life science investigations. Unlike the Soviet Mir space station, the US/ISS has been designed for extensive externally attached payloads; its platforms include elements in polar orbit and coorbital with the core station. The possibility of a Shuttle launched and Shuttle visited multiuser platform is discussed as well as the possible development of a Space Station module capable of substantial free-flying operations. K.K.

A88-15868*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
SPACE STATION ACCOMMODATION OF ATTACHED PAYLOADS
RONALD K. BROWNING and JANETTE C. GERVIN (NASA, Goddard Space Flight Center, Greenbelt, MD) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 7 p.
(IAF PAPER 87-97)

The Attached Payload Accommodation Equipment (APAE), which provides the structure to attach payloads to the Space Station truss assembly, to access Space Station resources, and to orient payloads relative to specified targets, is described. The main subelements of the APAE include a station interface adapter, payload interface adapter, subsystem support module, contamination monitoring system, payload pointing system, and attitude determination system. These components can be combined to provide accommodations for small single payloads, small multiple payloads, large self-supported payloads, carrier-mounted payloads, and articulated payloads. The discussion also covers the power, thermal, and data/communications subsystems and operations. V.L.

A88-15875*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
SPACE STATION SERVICES AND DESIGN FEATURES FOR USERS
PETER R. KURZHALS and ROYCE L. MCKINNEY (McDonnell Douglas Astronautics Co., Space Station Div., Huntington Beach, CA) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 11 p.
(Contract NAS9-17367)
(IAF PAPER 87-99)

The operational design features and services planned for the NASA Space Station will furnish, in addition to novel opportunities and facilities, lower costs through interface standardization and automation and faster access by means of computer-aided integration and control processes. By furnishing a basis for large-scale space exploitation, the Space Station will possess industrial production and operational services capabilities that may be used by the private sector for commercial ventures; it could also ultimately support lunar and planetary exploration spacecraft assembly and launch facilities. O.C.

A88-16993
POINTING MOUNT WITH ACTIVE VIBRATION ISOLATION FOR LARGE PAYLOADS
BRIAN J. HAMILTON, JAMES H. ANDRUS, and DELANO R. CARTER (Honeywell, Inc., Sperry Aerospace and Marine, Phoenix, AZ) IN: Guidance and control 1987; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Jan. 31-Feb. 4, 1987. San Diego, CA, Univelt, Inc., 1987, p. 299-318. refs
(AAS PAPER 87-033)

The paper presents a single-axis brassboard model of a dual-mode pointing mount which provides the high performance active isolation of magnetic suspension technology without the limitations on articulation normally imposed by small magnetic gaps. The equipment was designed to provide fast feedforward positioning forces in excess of 1000 pounds while simultaneously offering -80 dB of isolation over a wide frequency range and allowing several inches of travel between the carrier and the suspended body. Comparison of brassboard performance to analysis revealed a thorough analytical understanding of the linear and nonlinear dynamics of the system actuators. K.K.

A88-21080
SPACE STATION HABITAT AND LABORATORY MODULE RACK FLIGHT TESTING IN THE SPACEHAB MODULE
ROBERT CITRON and THOMAS C. TAYLOR (Spacehab, Inc., Seattle, WA) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 12 p. refs
(SAE PAPER 871416)

The Spacehab Module is a pressurized volume scheduled to be launched by the Space Shuttle and providing an opportunity for the flight testing of Space Station hardware prior to deployment of the hardware to the IOC Space Station. The module will be available in 1990 and can provide a variety of support systems designed to reduce the technical development risk to Space Station participants. The Spacehab Module flight testing capability simulating the Space Station interior environment is expected to be available five years before Initial Operating Configuration, creating a low cost, lower risk development lead-in rack testing capability for the commercial customer anticipating activities at Space Station. Author

A88-26210*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
SPACE STATION PROGRAM THREAT AND VULNERABILITY ANALYSIS
STEVEN D. VAN METER (NASA, Kennedy Space Center, Cocoa Beach, FL) and JOHN D. VEATCH (Science Applications International Corp., Safeguards and Security Div., McLean, VA) IN: Applying technology to systems; Aerospace Computer Security Conference, 3rd, Orlando, FL, Dec. 7-11, 1987, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 104-107.
(AIAA PAPER 87-3062)

An examination has been made of the physical security of the Space Station Program at the Kennedy Space Center in a peacetime environment, in order to furnish facility personnel with threat/vulnerability information. A risk-management approach is used to prioritize threat-target combinations that are characterized in terms of 'insiders' and 'outsiders'. Potential targets were identified and analyzed with a view to their attractiveness to an adversary, as well as to the consequentiality of the resulting damage. O.C.

A88-26420
SPACE STATION ASSEMBLY - TECHNIQUES AND STRUCTURES
E. J. PELKA (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) Lockheed Horizons (ISSN 0458-6773), Dec. 1987, p. 32-49.

Two Lockheed independent research and development projects are discussed. The first, Space Station Assembly Technology, addresses on-orbit structural assembly from the viewpoint of the EVA astronaut and emphasizes human factors engineering, operations, and EVA optimization. The second, Aluminum-Clad Graphite/Epoxy Struts, stresses areas of materials, structures, and manufacturing in the production of full-scale prototype truss elements that can be fine-tuned to a zero coefficient of thermal expansion after the metal/composite strut has been produced. It is shown that as the Space Station physical characteristics will continue to change, the Station's subsystems, ground support systems, and operations methods must similarly evolve to accommodate technological advances. A.S.

N88-15829*# Lockheed Missiles and Space Co., Sunnyvale, Calif. Bioastronautics.
SPACE STATION ACCOMMODATIONS FOR LIFE SCIENCES RESEARCH FACILITIES. PHASE 1: CONCEPTUAL DESIGN AND PROGRAMMATICS STUDIES FOR MISSIONS SAAX0307, SAAX0302 AND THE TRANSITION FROM SAAX0307 TO SAAX0302. VOLUME 2: STUDY RESULTS Final Report
31 Mar. 1986 143 p
(Contract NAS8-35472)
(NASA-CR-179244; NAS 1.26:179244; LMSC/F071319A-VOL-2)
Avail: NTIS HC A07/MF A01 CSCL 22B

Lockheed Missiles and Space Company's conceptual designs and programmatics for a Space Station Nonhuman Life Sciences Research Facility (LSRF) are presented. Conceptual designs and programmatics encompass an Initial Orbital Capability (IOC) LSRF, a growth or follow-on Orbital Capability (FOC), and the transitional process required to modify the IOC LSFR to the FOC LSFR. The IOC and FOC LSFRs correspond to missions SAAX0307 and SAAX0302 of the Space Station Mission Requirements Database, respectively. Author

N88-17721*# Boeing Aerospace Co., Seattle, Wash.
SYSTEM ANALYSIS STUDY OF SPACE PLATFORM AND STATION ACCOMMODATIONS FOR LIFE SCIENCES RESEARCH FACILITIES. VOLUME 1: EXECUTIVE SUMMARY. PHASE A: CONCEPTUAL DESIGN AND PROGRAMMATICS Final Report
Oct. 1985 43 p
(Contract NAS8-35471)
(NASA-CR-179268; NAS 1.26:179268; D180-27863-1-VOL-1; DPD-614-VOL-1; DR-5-VOL-1) Avail: NTIS HC A03/MF A01 CSCL 22B

The study was conducted in 3 parts over a 3 year period. The study schedule and the documentation associated with each study part is given. This document summarized selected study results from the conceptual design and programmatics segment of the effort. The objectives were: (1) to update requirements and tradeoffs and develop a detailed design and mission requirements document; (2) to develop conceptual designs and mission descriptions; and (3) to develop programmatic, i.e., work breakdown structure and work breakdown structure dictionary, estimated cost, and implementing plans and schedules. Author

N88-18742*# Teledyne Brown Engineering, Huntsville, Ala.
MICROGRAVITY AND MATERIALS PROCESSING FACILITY STUDY (MMPF): REQUIREMENTS AND ANALYSES OF COMMERCIAL OPERATIONS (RACO) PRELIMINARY DATA RELEASE
3 Mar. 1988 693 p
(Contract NASA-36122)
(NASA-CR-179309; NAS 1.26:179309) Avail: NTIS HC A99/MF E03 CSCL 12A

This requirements and analyses of commercial operations (RACO) study data release reflects the current status of research activities of the Microgravity and Materials Processing Facility under Modification No. 21 to NASA/MSFC Contract NAS8-36122. Section 1 includes 65 commercial space processing projects suitable for deployment aboard the Space Station. Section 2 contains reports of the R:BASE (TM) electronic data base being used in the study, synopses of the experiments, and a summary of data on the experimental facilities. Section 3 is a discussion of video and data compression techniques used as well as a mission timeline analysis. Author

N88-19571*# Lockheed Missiles and Space Co., Sunnyvale, Calif. Bioastronautics Dept.
SPACE STATION ACCOMMODATIONS FOR LIFE SCIENCES RESEARCH FACILITIES: PHASE A CONCEPTUAL DESIGN AND PROGRAMMATICS STUDIES FOR MISSIONS SAAX0307, SAAX0302 AND THE TRANSITION FROM SAAX0307 TO SAAX0302. VOLUME 1: EXECUTIVE SUMMARY Final Report
31 Mar. 1986 34 p
(Contract NAS8-35472)
(NASA-CR-179267; NAS 1.26:179267; LMSC/F071387-VOL-1)
Avail: NTIS HC A03/MF A01 CSCL 22B

The conceptual designs and programmatics for a Space Station Nonhuman Life Sciences Research Facility (LSRF) are highlighted. Conceptual designs and programmatics encompass an Initial Orbital Capability (IOC) LSRF, a growth or Follow-on Orbital Capability (FOC), and the transitional process required to modify the IOC LSRF to the FOC LSRF. B.G.

14

GROWTH

Includes descriptions of scenarios, analyses and system technology requirements for the evolutionary growth of the Space Station system.

A88-13974
LOOKING TO YEAR 2001
MICHAEL WILHITE Spaceflight (ISSN 0038-6340), vol. 29, Oct. 1987, p. 48-53.

The space programs of different countries are reviewed and ongoing developments in launch vehicle capability and manned space operations are identified. The primary feature of the new Soviet rocket Energia is its role as the booster for the Soviet Space Shuttle which is expected to lift up to 66,000 pounds of cargo. A small spaceplane has been developed which will replace the Soyuz-TM spacecraft in 1991 as a crew and limited-cargo transport to Mir. Space policy in the U.S. is discussed as well as

the International Space Station, the return of expendable launchers, the evolution of Ariane, a European manned program, Japan's manned space goals, and India's domestic programs. K.K.

A88-15847#
POSSIBILITIES FOR A EUROPEAN EVOLUTIONARY SPACE INFRASTRUCTURE
R. C. PARKINSON (British Aerospace, PLC, Space and Communications Div., Stevenage, England) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 5 p.
(IAF PAPER 87-68)

Key areas of space technology in which Europe will eventually want independent parallel capability are identified. The paper presents study of potential routes to this end. A key issue lies in the operational costs associated with permanent in-orbit facilities. These costs must be reduced if the construction of a permanent Space Infrastructure is not to freeze the available European budget and inhibit further developments. There is an intimate relationship between the operational costs of a Space Station and that of the space transportation system supporting it, and the two must be developed as a related package. The development of an independent European capability could encourage effective European participation in more advanced international Space programs in the 21st century. Author

A88-15871#
TRENDS TO REDUCE DEVELOPMENT AND OPERATION COSTS FOR EXPERIMENTS OF THE FUTURE SPACE LABORATORY
GIUSEPPE VIRIGLIO, GUSTAVO OELKER, FRANCESCO BETTOJA, and RAYMOND BATE (Aeritalia S.p.A., Turin, Italy) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 5 p.
(IAF PAPER 87-100)

Ways of reducing the costs of future experiments in the Space Station laboratories are discussed with reference to the following cost categories: hardware development, production, and preparation for flight; launch, including supply of consumables; crew services; operations; and communications between the various ground centers. To limit the costs of performing experiments in space, it is recommended that the users avoid complex hardware design, use as much common components as possible, design for light weight and low power consumption, and maximize automation and teleoperation. V.L.

A88-15872*# National Aeronautics and Space Administration, Washington, D.C.
EVOLUTIONARY SPACE STATION INFRASTRUCTURE
ALPHONSO V. DIAZ and BARBARA S. ASKINS (NASA, Office of Space Station, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 8 p.
(IAF PAPER 87-103)

This paper discusses the approach to Space Station evolution planning and the preliminary analysis of options for the evolution of the infrastructure. The approach emphasizes the analysis of evolution paths, driven by specific user requirements, and evolution modes, i.e., the infrastructure required to support the evolution paths. The objective is to determine the near-term actions that must be taken to protect the future options. These include the identification of evolution 'hooks and scars' on the baseline Space Station and the establishment of an evolution advanced development program. The near term emphasis of the evolution planning is on methods of increasing the efficiency and productivity of the Space Station and on requirements to support new initiatives currently being studied by NASA. Author

A88-16097*# National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.
MANNED MARS MISSION ACCOMODATION BY THE EVOLUTIONARY SPACE STATION
E. BRIAN PRITCHARD and ROBERT N. MURRAY (NASA, Langley Research Center, Hampton, VA) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 11 p.
(IAF PAPER 87-438)

It is shown that an unmanned launch capability of about 90 metric tons to the Space Station altitude and inclination is required to support the buildup of the manned Mars mission. The paper presents details of the assembly sequence including the analysis and conceptual design of additional truss and other facilities required at the Space Station. It is noted that the The Critical Evaluation Task Force configuration (dual keel) can evolve to accommodate the Mars space vehicle buildup. K.K.

A88-16156*# National Aeronautics and Space Administration, Washington, D.C.
ARTIFICIAL GRAVITY - A COUNTERMEASURE FOR ZERO GRAVITY
A. E. NICOGOSSIAN and P. D. MCCORMACK (NASA, Office of Space Science and Applications, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 10 p. refs
(IAF PAPER 87-533)

Current knowledge on artificial gravity is presented with emphasis placed on the unique characteristics of such an environment and their effects on crew performance and vehicle habitability. A parametric optimization of the vehicle size and operation is performed. The following set of 'optimum' parameter values is obtained: a cost of 15.8 billion dollars, a radius of 80 feet, a rotation rate of 4.8 rpm, and a g-value of 0.62. Consideration is also given to the problems of adaptation, retention of adaptation, and simultaneous adaptation to both nonrotating and rotating environments. K.K.

A88-16237#
PROJECT HORIZON - AN EARLY STUDY OF A LUNAR OUTPOST
FREDERICK I. ORDWAY, III, MITCHELL R. SHARPE (Alabama Space and Rocket Center, Tranquility Base, Huntsville), and RONALD C. WAKEFORD (U.S. Army, Corps of Engineers Technical Committee, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 32 p. refs
(IAF PAPER 87-659)

Project Horizon was a pioneering study prepared by the US Army in the late 1950s to further the exploration of space. It strived to (1) design and establish a lunar outpost from which further investigations of, and operations on, the lunar surface could be undertaken, and (2) provide a supporting capability for other operations in space. Consideration is given to the lunar outpost design and construction, scientific programs proposed to be undertaken on the moon, launch and transfer vehicles, launch facilities, and communications. Background facts on Project Horizon are also described. K.K.

A88-22044*# Martin Marietta Corp., Denver, Colo.
HUMAN EXPLORATION OF MARS
BENTON C. CLARK (Martin Marietta Planetary Sciences Laboratory, Denver, CO) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 6 p. refs
(Contract NAS8-37126)
(AIAA PAPER 88-0064)

A systems study is underway of astronaut missions to Mars that could be accomplished over the next four decades. In addition to an emphasis on the transportation and facility infrastructure required for such missions, other relevant technologies and mission constraints are also being considered. These induce on-orbit assembly, trajectory type, launch opportunities, propellant storage, crew size, cabin pressure, artificial gravity, life-support systems, radiation hazards, power/energy storage, thermal control, human factors, communications, abort scenarios, landing techniques, exploration strategies, and science activities. A major objective of the study is to identify enabling and significantly enhancing technologies for accomplishing the goal of the human exploration of Mars. Author

A88-28864
SOLAR SAILS AND THE ARSAT SATELLITE - SCIENTIFIC APPLICATIONS AND TECHNIQUES [LES VOILES SOLAIRES ET LE SATELLITE ARSAT - APPLICATIONS SCIENTIFIQUES ET TECHNIQUES]
CHRISTIAN MARCHAL L'Aeronautique et l'Astronautique (ISSN 0001-9275), no. 127, 1987, p. 53-57. In French.

The principle of the solar sail and projected applications for the space-deployable Arsat solar sail satellite are discussed. Their maneuverability, large size, reflector properties, and navigability, make solar sails ideal for the study of regions near the sun or those far away from the ecliptic plane. The 150-kg Arsat satellite has four inflatable masts and an area loading of 84 g/sq m, a value which is projected to be reduced to 20-30 g/sq m for more extended missions. Other applications include the elimination of debris in both geostationary and low orbits and the permanent support of geostationary satellites below a pole. R.R.

A88-29196* Los Alamos National Lab., N. Mex.
A LUNAR LABORATORY
P. W. KEATON (Los Alamos National Laboratory, NM) and M. B. DUKE (NASA, Johnson Space Center, Houston, TX) (COSPAR, IAU, IUGS, et al., Plenary Meeting, 26th, Topical Meeting C3, Workshop III, and Symposium 8 on Planetary Studies, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 7, no. 12, 1987, p. 175-183. Previously announced in STAR as N87-12580. refs

An international research laboratory can be established on the Moon in the early years of the 21st Century. It can be built using the transportation system now envisioned by NASA, which includes a space station for Earth orbital logistics and orbital transfer vehicles for Earth-Moon transportation. A scientific laboratory on the Moon would permit extended surface and subsurface geological exploration; long-duration experiments defining the lunar environment and its modification by surface activity; new classes of observations in astronomy; space plasma and fundamental physics experiments; and lunar resource development. The discovery of a lunar source for propellants may reduce the cost of constructing large permanent facilities in space and enhance other space programs such as Mars exploration. D.E.

A88-29237
SPACE FARMING IN THE 21ST CENTURY
FRANK B. SALISBURY and BRUCE G. BUGBEE (Utah State University, Logan) Twenty-first Century Science and Technology (ISSN 0895-6820), vol. 1, Mar.-Apr. 1988, p. 32-41. refs

An account is given of the system design features and projected productivity of a fusion-powered farm on the moon, dubbed 'Luna City'. Attention is given to the rationale for nuclear fusion power and to the nutritional and cultural criteria applied to crop evaluation, as well as to plant physiological responses to the entirely artificial environment, and the cuisine that could be based on the crops in question. Legumes, salad crops, leaf and flower crops, sugar-precursors, nuts, roots and tubers, grains, fruits, oil-bearing crops, and herbs and spices, are all included in the plan for Luna City. O.C.

N88-10084*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACECRAFT 2000
Jul. 1986 236 p Workshop held in Cleveland, Ohio, 29-31 Jul. 1986
(NASA-CP-2473; E-3358; NAS 1.55:2473) Avail: NTIS HC A11/MF A01 CSCL 22B

The objective of the Workshop was to focus on the key technology area for 21st century spacecraft and the programs needed to facilitate technology development and validation. Topics addressed include: spacecraft systems; system development; structures and materials; thermal control; electrical power; telemetry, tracking, and control; data management; propulsion; and attitude control.

N88-10819*# National Academy of Sciences - National Research Council, Washington, D. C. Committee on Advanced Space Technology.
SPACE TECHNOLOGY TO MEET FUTURE NEEDS
1987 183 p Original contains color illustrations
(Contract NASW-4003)
(NASA-CR-181473; NAS 1.26:181473) Avail: NTIS HC A09/MF A01 CSCL 22A

Key technologies were identified where contemporary investments might have large payoffs in technological options for the future. The future needs were considered for space transportation, space science, national security, and manned missions. Eight areas were selected as being vital for the national future in space. Findings regarding representative mission and the recommendations concerning high priority technologies are summarized. B.G.

N88-11736*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Aerospace and Ocean Engineering.
AEROASSISTED MANNED TRANSFER VEHICLE (TAXI) FOR ADVANCED MARS TRANSPORTATION: NASA/USRA 1987 SENIOR DESIGN PROJECT
1987 245 p Sponsored by NASA, Washington, D.C. and Universities Space Research Association
(NASA-CR-181478; NAS 1.26:181478) Avail: NTIS HC A11/MF A01 CSCL 22B

A conceptual design study of an aeroassisted orbital transfer vehicle is discussed. Nicknamed TAXI, it will ferry personnel and cargo: (1) between low Earth orbit and a spacecraft circling around the Sun in permanent orbit intersecting gravitational fields of Earth and Mars, and (2) between the cycling spacecraft and a Mars orbiting station, co-orbiting with Phobos. Crew safety and mission flexibility (in terms of ability to provide a wide range of delta-V) were given high priority. Three versions were considered, using the same overall configuration based on a low L/D aerobrake with the geometry of a raked off elliptical cone with ellipsoidal nose and a toroidal skirt. The propulsion system consists of three gimballed LOX/LH2 engines firing away from the aerobrake. The versions differ mainly in the size of the aeroshields and propellant tanks. TAXI A version resulted from an initial effort to design a single transfer vehicle able to meet all delta-V requirements during the 15-year period (2025 to 2040) of Mars mission operations. TAXI B is designed to function with the cycling spacecraft moving in a simplified, nominal trajectory. On Mars missions, TAXI B would be able to meet the requirements of all the missions with a relative approach velocity near Mars of less than 9.3 km/sec. Finally, TAXI C is a revision of TAXI A, a transfer vehicle designed for missions with a relative velocity near Mars larger than 9.3 km/sec. All versions carry a crew of 9 (11 with modifications) and a cargo of 10000 lbm. Trip duration varies from 1 day for transfer from LEO to the cycling ship to nearly 5 days for transfer from the ship to the Phobos orbit. Author

N88-14907*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE STATION ACCOMMODATIONS FOR LUNAR BASE ELEMENTS: A STUDY
DEENE J. WEIDMAN, WILLIAM CIRILLO, CHARLES LLEWELLYN, MARTIN KASZUBOWSKI, and E. MICHAEL KIENLEN, JR. (National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.) Oct. 1987 246 p
(NASA-TM-100501; NAS 1.15:100501) Avail: NTIS HC A11/MF A01 CSCL 22B

The results of a study conducted at NASA-LaRC to assess the impact on the space station of accommodating a Manned Lunar Base are documented. Included in the study are assembly activities for all infrastructure components, resupply and operations support for lunar base elements, crew activity requirements, the effect of lunar activities on Cape Kennedy operations, and the effect on space station science missions. Technology needs to prepare for such missions are also defined. Results of the study indicate that the space station can support the manned lunar

base missions with the addition of a Fuel Depot Facility and a heavy lift launch vehicle to support the large launch requirements. Author

N88-17567# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Systems and Logistics.
CRITICAL ISSUES FOR ESTABLISHMENT OF A PERMANENTLY-OCCUPIED LUNAR BASE M.S. Thesis
PAUL C. KENT, II Sep. 1987 124 p
(AD-A187128; AFIT/GSM/LSPA/87S-13) Avail: NTIS HC A06/MF A01 CSCL 05A

The purpose of this study was to determine the critical issues for a potential lunar outpost by polling a group of experts knowledgeable about decision-making involving the allocation of large-scale resources. A Delphi exercise is an iterative polling technique in which the group opinion is refined during successive iterations, while at the same time preserving differing viewpoints. The experts identified four critical issues: (1) demonstration of the value of a lunar base (e.g., cost effective lunar-based science, source of raw materials, technology spin-offs, etc.); (2) sustained political and financial support; (3) credibility of the government (i.e., NASA) in accomplishing such a large and complex program; (4) development of the military value of a lunar base. GRA

N88-18606*# Auburn Univ., Ala. Dept. of Aerospace Engineering.
A TWO STAGE LAUNCH VEHICLE FOR USE AS AN ADVANCED SPACE TRANSPORTATION SYSTEM FOR LOGISTICS SUPPORT OF THE SPACE STATION Final Report
Jun. 1987 315 p Sponsored by NASA, Marshall Space Flight Center, Huntsville, Ala.
(NASA-CR-182572; NAS 1.26:182572) Avail: NTIS HC A14/MF A01 CSCL 22B

This report describes the preliminary design specifications for an Advanced Space Transportation System consisting of a fully reusable flyback booster, an intermediate-orbit cargo vehicle, and a shuttle-type orbiter with an enlarged cargo bay. It provides a comprehensive overview of mission profile, aerodynamics, structural design, and cost analyses. These areas are related to the overall feasibility and usefulness of the proposed system. Author

N88-18608*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ASSESSMENT OF MIXED FLEET POTENTIAL FOR SPACE STATION LAUNCH AND ASSEMBLY
L. J. DERYDER, ed. Dec. 1987 134 p
(NASA-TM-100550; NAS 1.15:100550) Avail: NTIS HC A07/MF A01 CSCL 22B

Reductions in expected STS flight rates of the Space Shuttle since the 51-L accident raise concerns about the ability of available launch capacity to meet both payload-to-orbit and crew rotation requirements for the Space Station. In addition, it is believed that some phases of Station build-up could be expedited using unmanned launch systems with significantly greater lift capacity than the STS. Examined is the potential use of expendable launch vehicles (ELVs), yet-to-be-developed unmanned shuttle-derived vehicles (SDVs), and international launch vehicles for meeting overall launch requirements to meet Space Station program objectives as defined by the 1986 Critical Evaluation Task Force (CETF). The study concludes that use of non-STS transportation can help meet several important program objectives as well as reduce the total number of STS flights. It also finds, however, that reduction of Space Station-dedicated STS flights below 8 per year forces a reduction in Station crew size assuming the CETF 90 day crew stay time baseline and seriously impairs scientific utilization of the Station. Author

N88-19379*# Auburn Univ., Ala. Dept. of Aerospace Engineering.
A LUNAR TRANSPORTATION SYSTEM
Jun. 1988 94 p
(Contract NGT-21-002-080)
(NASA-CR-182561; NAS 1.26:182561) Avail: NTIS HC A05/MF A01 CSCL 13F

Due to large amounts of oxygen required for space travel, a method of mining, transporting, and storing this oxygen in space would facilitate further space exploration. The following project deals specifically with the methods for transporting liquid oxygen from the lunar surface to the Lunar Orbit (LO) space station, and then to the Lower Earth Orbit (LEO) space station. Two vehicles were designed for operation between the LEO and LO space stations. The first of these vehicles is an aerobraked design vehicle. The Aerobrake Orbital Transfer Vehicle (OTV) is capable of transporting 5000 lbm of payload to LO while returning to LEO with 60,000 lbm of liquid oxygen, and thus meet mission requirements. The second vehicle can deliver 18,000 lbm of payload to LO and is capable of bringing 60,000 lbm of liquid oxygen back to LEO. A lunar landing vehicle was also designed for operation between LO and the established moon base. The use of an electromagnetic railgun as a method for launching the lunar lander was also investigated. The feasibility of the railgun is doubtful at this time. A system of spheres was also designed for proper storing and transporting of the liquid oxygen. The system assumes a safe means for transferring the liquid oxygen from tank to tank is operational. A sophisticated life support system was developed for both the OTV and the lunar lander. This system focuses on such factors as the vehicle environment, waste management, water requirements, food requirements, and oxygen requirements. Author

N88-19580*# Bionetics Corp., Hampton, Va.
ANALYSIS OF A ROTATING ADVANCED-TECHNOLOGY SPACE STATION FOR THE YEAR 2025 Contractor Report, Nov. 1986 - Apr. 1987
M. J. QUEIJO, A. J. BUTTERFIELD, W. F. CUDDIHY, C. B. KING, R. W. STONE, and P. A. GARN Jan. 1988 244 p
(Contract NAS1-18267)
(NASA-CR-178345; NAS 1.26:178345) Avail: NTIS HC A11/MF A01 CSCL 22B

An analysis is made of several aspects of an advanced-technology rotating space station configuration generated under a previous study. The analysis includes examination of several modifications of the configuration, interface with proposed launch systems, effects of low-gravity environment on human subjects, and the space station assembly sequence. Consideration was given also to some aspects of space station rotational dynamics, surface charging, and the possible application of tethers. Author

15

MISSIONS, TETHERS, AND PLATFORMS

Includes descriptions and requirements of missions and tethers onboard the Space Station and platforms that are either co-orbiting with the Space Station, in polar orbit, or in geosynchronous orbit and which are part of the Space Station system.

A88-11234
STABILITY OF THE STEADY MOTIONS OF AN ELECTROMAGNETIC TETHER SYSTEM IN ORBIT [OB USTOICHIVOSTI STATSIONARNYKH DVIZHENII ELEKTROMAGNITNOI TROSOVOI SISTEMY NA ORBITE]
E. M. LEVIN Kosmicheskie Issledovania (ISSN 0023-4206), vol. 25, July-Aug. 1987, p. 491-501. In Russian. refs

The motion of two satellites connected by a current-carrying tether in geocentric orbit is investigated. The interaction of the tether current with the geomagnetic field can either generate electric power or produce low thrust. The effect of electromagnetic forces distributed along the tether on the dynamics of the tether system is examined using a model of two material points connected

by an extensible flexible thread. In the case of direct current, the presence of these forces leads to an instability of the steady motions of the tether system. Stabilization can be achieved by controlling the current force in the tether. B.J.

A88-11726*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CAPTURE-EJECTOR SATELLITES
IAN MACCONOCHIE, CHARLES H. ELDRED, and JAMES A. MARTIN (NASA, Langley Research Center, Hampton, VA) (SAWE, Annual Conference, 41st, San Jose, CA, May 17-19, 1982, SAWE Paper 1455) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, July-Aug. 1987, p. 289, 290. Abridged. Previously cited in issue 21, p. 3291, Accession no. A82-43265.

A88-11880#
POWER AND RESOURCE MANAGEMENT SCHEDULING FOR SCIENTIFIC SPACE PLATFORM APPLICATIONS
AMY L. GEOFFROY, DANIEL L. BRITT, ELLEN A. BAILEY, and JOHN GOHRING (Martin Marietta Corp., Martin Marietta Data Systems Group, Bethesda, MD) IN: IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volume 2. New York, American Institute of Aeronautics and Astronautics, 1987, p. 660-664.

The MAESTRO scheduling system designed to handle resource-constrained scheduling problems is described. The MAESTRO system uses activity models, a scheduling period, resource availability profiles, conditions profiles, and an activity list as inputs and a time line of scheduled activities, updated resource availability profiles, evaluations of the computed schedules, and a listing of activities by success level as outputs. The operations of the system are: activity selection, activity placement, resource profile updates, and contingency handling. The user interactions and interface of the system are examined. The effects of strategy selection on the schedule output are investigated, and methods for handling power efficiency under different scheduling scenarios are proposed. I.F.

A88-13164* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
RESEARCH OPPORTUNITIES IN MICROGRAVITY SCIENCE AND APPLICATIONS DURING SHUTTLE HIATUS
BRUCE N. ROSENTHAL, THOMAS GLASGOW (NASA, Lewis Research Center, Cleveland, OH), RICHARD E. BLACK (NASA, Marshall Space Flight Center, Huntsville, AL), and DANIEL E. ELLEMAN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Advanced materials technology '87; Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr. 6-9, 1987. Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 506-516. Previously announced in STAR as N87-16917. refs

The opportunity to conduct microgravity and related research still exists, even with the temporary delay in the U.S. Space Shuttle program. Several ground-based facilities are available, and use of these facilities is highly recommended for the preparation of near and far term Shuttle or Space Station experiments. Drop tubes, drop towers, aircraft, sounding rockets, and a wide variety of other ground-based equipment can be used to simulate microgravity. This paper concentrates on the materials processing capabilities available at NASA Lewis Research Center (NASA Lewis), Marshall Space Flight Center (MSFC), and the California Institute of Technology Jet Propulsion Laboratory (JPL). Also included is information on gaining access to these facilities. Author

A88-15511#
MIRRABOOKA X-RAY DETECTOR AND SPACECRAFT DESIGN STUDY
J. A. S. RAJU (Hawker de Havilland Australia Pty., Ltd., Bankstown) IN: National Space Engineering Symposium, 2nd, Sydney, Australia, Mar. 25-27, 1986, Preprints. Volume 2. Barton, Australia/Brookfield, VT, Institution of Engineers, Australia/Brookfield Publishing Co., 1986, 16 p.

The current status of design efforts for the Mirrabooka wideband X-ray astronomy satellite, being developed in Australia for Space Shuttle launch, is surveyed. Mirrabooka is based on the NASA Spartan reusable free-flyer platform, so that the design must satisfy not only the science requirements but also the payload-accomodation requirements of Spartan. Topics addressed include the components of the high-energy detector (pressure vessel, wire array, graded shield, collimator, and window), payload integration, and safety compliance. Drawings, diagrams, and tables of numerical data are provided. T.K.

A88-15802#
CONCEPTUAL DESIGN OF THE ADVANCED TECHNOLOGY PLATFORM
RYOICHI IMAI, MASANORI HOMMA, and NORIKAZU HARA (National Space Development Agency of Japan, Tokyo) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 10 p.
(IAF PAPER 87-02)

This paper presents the concept of the ATP (Advanced Technology Platform) which is a co-orbiting platform planned to be launched in 1995. The ATP has two major objectives. One is to establish the advanced technologies essential to the future space platforms. The other is to conduct autonomous and in-orbit serviceable space experiments. To meet the various mission demands and to attain the high performance, the ATP adopts modular design, in-orbit servicing capability and advanced subsystem technologies. As subsystem technologies for the ATP, rendezvous-docking, two phase fluid loop thermal control and retractable flexible solar array are under development. The mission profile of the ATP is divided into two phases. Many space experiments such as material processing are conducted after the technology demonstration mission. Author

A88-15809#
ENVIRONMENTAL CONSTRAINTS FOR POLAR PLATFORM DESIGN
A. J. SIMS, P. R. TRUSCOTT, G. L. WRENN, and C. S. DYER (Royal Aircraft Establishment, Space Dept., Farnborough, England) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 11 p. refs
(IAF PAPER 87-09)

The energetic primary and secondary radiation environment to be expected for the Polar Platform is examined on the basis of some of the available environmental models and radiation transport codes. In particular, attention is given to plasma interactions, geomagnetically trapped radiation, cosmic rays and solar protons, and effects of shielding and estimation of energy deposition. Monitors which can improve the data base are described, and the need for further spacecraft charging studies is emphasized. V.L.

A88-15811#
COORBITATION OF FREE-FLYERS
FRANCK MARTEL (Aerospatiale, Les Mureaux, France) and PIERRE DUTTO (CNES, Toulouse, France) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 11 p. refs
(IAF PAPER 87-14)

By the next decade, during the operational life of space stations, free-flyer modules will fly on a closed orbit to the Station, in order to be serviced periodically. The principal strategies of coorbitation: (1) free-flying boomerang, (2) controlled altitude decrease, (3) permanent coorbitation (hold point), and (4) drag free, are examined under technical and operational aspects, including orbital dynamics, propellant consumption, operational flexibility, and constraints on the spacecraft. After presenting the orbital mechanics, numerical examples dealing with the U.S. International Space Station and the European Columbus free-flyer are given. Author

A88-15814*# Ford Aerospace and Communications Corp., Palo Alto, Calif.
GEOSTATIONARY EARTH OBSERVATIONS - PLATFORM OPERATIONS FROM THE SPACE STATION

NEIL BARBERIS and JOHN DIXSON (Ford Aerospace and Communications Corp., Palo Alto, CA) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 9 p.
(Contract NAS8-36104)
(IAF PAPER 87-19)

The ground, launch, and servicing operations associated with the deployment of a geostationary earth observation platform from the Space Station are discussed. The main features of a configuration developed for the next generation geostationary observation platform and its flight operations are reviewed. The total operational cost of the platform from initial launch, assembly, and test of the Space Station, and the geo insertion is estimated at $240M, with a subsequent servicing mission costing $123M. V.L.

A88-15828*# National Aeronautics and Space Administration, Washington, D.C.
HUBBLE SPACE TELESCOPE SERVICING - EXPERIENCE BASE FOR A NEW ERA
JAMES C. WELCH (NASA, Office of Space Science and Applications, Washington, DC) and WILLIAM W. BROWN (BDM Corp., Columbia, MD) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 9 p. refs
(IAF PAPER 87-38)

An account is given of the conceptual evolution of the Hubble Space Telescope's (HST) maintenance methodology, and the belated recognition of its long-term support requirements, as well as measures conceived for the extension of this orbiting observatory's service life, and the prospective benefits derivable by comparable programs from HST experience. Attention is given to HST cost and capability tradeoffs, the maintenance concept's definition, the integrated logistic support planning instituted by the program and its failure-prediction methods, as well as the institutional support base employed. O.C.

A88-15834#
TETHERED SPACE ELEVATOR - POSSIBLE APPLICATIONS AND DEMONSTRATIVE EXPERIMENTS
F. BEVILACQUA, P. MERLINA, and S. CIARDO (Aeritalia S.p.A., Settore Spazio, Turin, Italy) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 11 p. refs
(IAF PAPER 87-49)

Studies of the Tethered Space Elevator (TSE) are reviewed. Possible applications of the TSE are surveyed, and system topics are discussed. Key elements of the TSE and related technologies are described. Planned activities involving the TSE are addressed, demonstrating the key TSE features to be used in them. C.D.

A88-15835#
AN OPTICALLY TETHERED AND CONTROLLED SATELLITE SYSTEM
FRANK J. REDD (Utah State University, Logan), LLOYD ALLRED, and THOMAS S. SUMMERS (Space Systems Engineering, Logan, UT) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 6 p. Research supported by the State of Utah Center of Excellence and Learn, Inc. refs
(IAF PAPER 87-50)

A master/slave satellite system is considered in which attitude control information is provided to a cluster of slave satellites from a master satellite via optical linkages. The in-plane and out-of-plane relative motion of the slave satellites with respect to the master is studied, and the closed periodic nature of the three-dimensional motion is geometrically determined as a function of the relative initial conditions. Oblative effects are found to be negligible, while drag effects are shown to be significant if the ballistic coefficients of the slaves differ significantly from those of the master. The practical application of remote holographic image comparison to attitude determination is discussed, and a mathematical approach is proposed. R.R.

A88-15882#
OPERATIONAL UTILIZATION OF THE POLAR PLATFORMS
Y. LECUREUX, J. CORNET (Matra, S.A., Toulouse, France), and P. DUTTO (CNES, Toulouse, France) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 8 p.
(IAF PAPER 87-116)

An evaluation is conducted of various possible polar-orbiting platform-based mission scenarios, in light of both currently available and prospective instrumentation capabilities. Attention is given to operational constraints that emerge in (1) management and organizations; (2) overall system technical requirements that encompass data-handling, communications, and ground facilities; and (3) legal aspects. Alternative payload groupings and possible multimission scenarios are discussed. O.C.

A88-15894*# Science Research Council, Didcot (England).
SAFIRE - A NOVEL HIGH RESOLUTION COOLED SPECTROMETER FOR ATMOSPHERIC RESEARCH
J. E. HARRIES, T. W. BRADSHAW, P. F. GRAY, P. H. G. DICKINSON (SERC, Rutherford Appleton Laboratory, Didcot, England), J. M. RUSSELL, III, J. PARK (NASA, Langley Research Center, Hampton, VA), B. CARLI (CNR, Istituto per la Ricerca sulle Onde Elettromagnetiche, Florence, Italy) et al. IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 9 p.
(IAF PAPER 87-137)

The SAFIRE (Spectroscopy of Atmospheric Far Infra-Red Emissions) experiment is discussed with particular reference to the scientific aims and the conceptual instrument design of the project. The principal requirements of the experiment are reviewed, and it is shown how these requirements are met in the instrument concept. In particular, measurements of hydrogen oxides and other important species in the stratosphere require a far infrared limb sounder. Some problems involved in the optical and thermal design of the instrument are examined. V.L.

A88-15971#
ELECTRICAL CURRENT FLOW ACROSS THE TSS - THE CORE EQUIPMENT AND OTHER RELATED TECHNICAL ISSUES
C. BONIFAZI (CNR, Istituto di Fisica dello Spazio Interplanetario, Frascati, Italy), F. GIANI, and P. MUSI (Aeritalia S.p.A., Gruppo Sistemi Spaziali ed Energie Alternative, Turin, Italy) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 19 p. refs
(IAF PAPER 87-252)

Design features of the first Tethered Satellite System mission (TSS-1) which are relevant to future applications of the tether concept are considered, with emphasis on the use of tether systems for power and thrust generation. Perturbations induced in the ionospheric plasma by the electrical current flow across the TSS are investigated to study energy loss mechanisms associated with tether system power generation. The TSS-1 Core Equipment controls the electrical current flow through the tether, and it consists of a tether current-voltage control system and a three-axis accelerometer gyro. Tether system design is based on performance parameters including the power delivered to the generator user, the power generation efficiency, and the minimum no-sever probability. R.R.

A88-16014#
DYNAMICS AND CONTROL OF THE TETHERED SATELLITE SYSTEM IN THE PRESENCE OF OFFSETS
P. K. LAKSHMANAN, V. J. MODI (British Columbia, University, Vancouver, Canada), and A. K. MISRA (McGill University, Montreal, Canada) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 13 p. refs
(IAF PAPER 87-316)

A mathematical model is proposed here for studying the dynamics of the Tethered Satellite System (TSS) that consists of a plate-type Space Station from which a tether supported subsatellite is deployed or retrieved. The rigid body dynamics of the tether, subsatellite and Space Station are analyzed accounting for the mass of the tether as well as a three dimensional offset

of its point of attachment. Controllability of the linearized equations is established numerically and a comparative study of three different control strategies conducted. The strategies employ thrusters, tension in the tether line or motion of the offset of the attachment to achieve control of the system subjected to a relatively large initial disturbance. Results suggest that, in the stationkeeping mode, the tension control strategy damps a given disturbance in the shortest time, but at an expense of the energy. On the other hand, the offset control proves to be the most efficient in terms of energy consumption, but now the response to disturbance persists over a long duration. In addition, the performance of the thruster control and tension control strategies are analyzed during retrieval of the tether from different initial lengths. Author

A88-16061#
MICROGRAVITY RESEARCH AND USER SUPPORT IN THE SPACE STATION ERA - THE MICROGRAVITY USER SUPPORT CENTER
K. WITTMANN, H. P. SCHMIDT, and B. FEUERBACHER (DFVLR, Cologne, Federal Republic of Germany) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 15 p. refs
(IAF PAPER 87-390)

The organizational structure, objectives, and functions of the Microgravity User Support Center (MUSC) created in Cologne, FRG, jointly by the Institute for Aerospace Medicine, Institute for Space Simulation, and Institute for Materials Research are reviewed. The functions of integrated user support implemented at MUSC closely link scientific and technical tasks for support of experiments and evaluation with operational tasks to support experimental performance during the mission. These functions include user information, experiment preparation, flight experiment operations, and scientific support. The current status of the MUSC and future prospects are discussed. V.L.

A88-16082#
THE PROTEIN CRYSTALLIZATION FACILITY (PCF) FOR EURECA
ERHARD SCHOEN and FRANK SEIFERT (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, Federal Republic of Germany) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 6 p.
(IAF PAPER 87-412)

Research on the structure of molecules by X-ray diffraction analysis requires large single crystals. However, the dynamic behavior of proteins caused by their high molecular weight prevents the growth of large single crystals if this process is disturbed by thermal convection. For example, protein single crystals grown under terrestrial (1 g) conditions are limited to dimensions in the order of 0.1 mm, whereas the size of crystals, grown under (quasi) space conditions has been 5 times larger (pilot experiment Cryostat, Spacelab). Under Eureca conditions (e.g., no micron gravity disturbances), the result in regularity of crystal growth and size is expected to be much better. An overview is given of the Protein Crystallization Facility which includes experiment-, service- and secondary cooling module and its interfaces to the Eureca carrier. A short mission profile concerning cooling-, power-, and data exchange requirements is presented. Author

A88-16113*# Perkin-Elmer Corp., Danbury, Conn.
AN ADVANCED IMAGING SPACE TELESCOPE CONCEPT
MICHAEL H. KRIM (Perkin-Elmer Corp., Danbury, CT) and JAMES W. STEINCAMP (NASA, Marshall Space Flight Center, Huntsville, AL) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 9 p.
(IAF PAPER 87-460)

This paper describes the results of a recent study of possible configurations for a next-generation optical space telescope with order-of-magnitude improvements over the Hubble Space Telescope. Overall configuration characteristics including optical performance, weights, and dimensions are given. Launch vehicle packaging concepts are described, and a scenario for orbital assembly developed. Finally, an assessment of technology readiness is provided. Author

A88-16136#
DEVELOPMENT OF ON-BOARD SATELLITE COMMUNICATIONS EQUIPMENT IN THE GEOSTATIONARY PLATFORM ERA
HIROSHI UDA, YUICHI OTSU, NOBUO ISHIZU, KIMIO MIYASAKA (Satellite Communications Research Corp., Japan), and FUSAKI MATSUI (Ministry of Posts and Telecommunications, Tokyo, Japan) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 8 p.
(IAF PAPER 87-495)

The objectives and relevant key technologies of communications payload studies directed toward the Geostationary Communications Platform that are being carried out in Japan are reviewed. In particular, attention is given to land mobile satellite communications, development of a large antenna, development of a solid-state power amplifier, millimeter-wave personal satellite communications, and the development of TWT and low-noise amplifiers. The discussion also covers the development of a high-stability oscillator, enhanced/regional direct broadcasting, and other technical development programs. V.L.

A88-16221#
SPACEHAB'S COMMERCIALIZATION OF MICROGRAVITY RESEARCH ACTIVITIES
THOMAS C. TAYLOR (SPACEHAB, Inc., Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 10 p. refs
(IAF PAPER 87-629)

Spacehab, a module in the Space Shuttle offering a man-tended research capability, is discussed. The commercial market in space and Spacehab's possible role in speeding up its slow development are addressed. The lower costs of Spacehab in comparison with other alternatives are pointed out. The reduction of risks involved in the development of the Space Station is considered, and a proposed development scenario involving Spacehab is described. The basic design of Spacehab is briefly presented. C.D.

A88-16285
FAULT TOLERANT ONBOARD IMPLEMENTATION OF CONTROL PROCEDURES IN TETHERED SATELLITE
R. RANIERI, G. GIANNINI, A. AIRAGHI, and D. FOSSATI (Si-El S.p.A., Milan, Italy) IN: Automatic control in space 1985. Oxford and New York, Pergamon Press, 1986, p. 67-74. refs

The Space Shuttle's Tethered Satellite requires general spacecraft management, autonomous data handling, and safety precautions for both the Shuttle and the satellite. Fault tolerance is implemented via a process of task-migration between two processors in the event of a failure in either. The two microprocessors have independent software packages, one for general spacecraft management and the other for attitude control. A backup software package is used when one of the two microprocessors is out of service. O.C.

A88-16294
ON CONTROL OF TETHERED SATELLITE SYSTEMS
A. K. MISRA, D. M. XU (McGill University, Montreal, Canada), and V. J. MODI (British Columbia, University, Vancouver, Canada) IN: Automatic control in space 1985. Oxford and New York, Pergamon Press, 1986, p. 145-151. refs

The dynamics of tethered satellite systems is rather complex and consists of various rotational and vibrational degrees of freedom. While designing its control system, some of these degrees of freedom may be modeled while the others are likely to be left unmodeled to reduce complexity and cost. This paper examines the effectiveness of control procedures based on lower order dynamical models, when applied to higher order models. It appears that if a tension control law or its derivative is to be used to control the tether dynamics, a reasonably higher order model including the transverse vibrations must be considered to synthesize the control system. Author

A88-16858
TETHERED SPACE SYSTEM - A NEW FACILITY FOR EXPERIMENTAL RAREFIED GAS DYNAMICS
F. BEVILACQUA and C. CHIARELLI (Aeritalia S.p.A., Turin, Italy) IN: International Symposium on Rarefied Gas Dynamics, 15th, Grado, Italy, June 16-20, 1986, Proceedings. Volume 1. Stuttgart, B. G. Teubner, 1986, p. 558-573. refs

The purpose of the present paper is to indicate the main aspects in terms of aerothermodynamic performance and technological solutions in designing a tethered atmospheric probe satellite as a facility for experimental gas dynamics. On the basis of the available atmosphere models and the theory of flying bodies in rarefied gases, the flow regimes experienceable by the tethered satellite module in its nominal mission and the behavior of a conventional thermal control design have been analyzed. For computing aerodynamic heating rates at lower altitudes, a probabilistic transitional flow model has been adopted. Design solutions employing nonconventional thermal protection techniques and high temperature insulating materials have been investigated. Author

A88-16859* Naples Univ. (Italy).
LOW DENSITY AEROTHERMODYNAMICS STUDIES PERFORMED BY MEANS OF THE TETHERED SATELLITE SYSTEM
GIOVANNI M. CARLOMAGNO, LUIGI DE LUCA (Napoli, Universita, Naples, Italy), PAUL M. SIEMERS, and GEORGE M. WOOD, JR. (NASA, Langley Research Center, Hampton, VA) IN: International Symposium on Rarefied Gas Dynamics, 15th, Grado, Italy, June 16-20, 1986, Proceedings. Volume 1. Stuttgart, B. G. Teubner, 1986, p. 574-585. refs

Low density gas flow modeling and current ground wind-tunnel technologies are not presently able to produce fully reliable data concerning low density flow regimes. In order to answer some of these issues, the Shuttle Continuous Open Wind Tunnel (SCOWT) program has been proposed, which makes use of the tethered satellite system (TSS). SCOWT's objective is to investigate the energy and momentum transfer between the tethered satellite and its environmental medium within the range of the thermofluid-dynamic conditions experienced by TSS during its atmospheric flights. The feasibility and capability of SCOWT to perform low density aerothermodynamics studies are investigated. Some of the results, obtained by means of a tether simulation program, and the instrumentation and TSS design main requirements to meet SCOWT objectives are described. Author

A88-16860
FEASIBILITY STUDY OF A STABILIZER FIN FOR THE TETHERED SATELLITE SYSTEM
A. ERCOLI FINZI, G. FIOCCHI (Milano, Politecnico, Milan, Italy), and R. TRUCCO (Aeritalia S.p.A., Turin, Italy) IN: International Symposium on Rarefied Gas Dynamics, 15th, Grado, Italy, June 16-20, 1986, Proceedings. Volume 1. Stuttgart, B. G. Teubner, 1986, p. 586-596. refs

This research was performed in order to design a stabilizer fin for the tethered satellite. The U.S. Standard Atmosphere '76 was used for determining the atmospheric characteristics. The flow regime was determined by the Knudsen number, on the basis of the mean free path computed both from the Standard Atmosphere and from the theory of gases in local thermodynamic equilibrium. In order to compute heat fluxes, the Stanton number was used, calculated both by the Reeves and the Von Camp theory and by the Monti theory. Author

A88-17026* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
REMOTE SENSING: EARTH'S SURFACE AND ATMOSPHERE; PROCEEDINGS OF WORKSHOP X AND THE TOPICAL MEETING OF THE 26TH COSPAR PLENARY MEETING, TOULOUSE, FRANCE, JUNE 30-JULY 11, 1986
W. D. CARTER, ED. (Globex, Inc., Reston, VA), A. ARKING, ED. (NASA, Goddard Space Flight Center, Greenbelt, MD), M. P. MCCORMICK, ED. (NASA, Langley Research Center, Hampton, VA), and E. RASCHKE, ED. (Koeln, Universitaet, Cologne, Federal Republic of Germany) Workshop and Meeting sponsored by COSPAR, International Union of Geological Sciences, UN, et al. Advances in Space Research (ISSN 0273-1177), vol. 7, no. 3, 1987, 259 p. In English and French. For individual items see A88-17027 to A88-17060.

The present conference on space-based remote sensing of the earth's surface and atmosphere addresses the two broad issues of remote sensing activities of interest to developing countries and the results obtained to date by the International Satellite Cloud Climatology Project, the Earth Radiation Budget Experiment, and the Stratospheric Aerosol and Gas Experiment (SAGE). Attention is given to the remote sensing of environmental factors affecting health, applications of satellite microwave radiometry, earth science missions for the NASA Space Station, and digitally produced Landsat map images. Also discussed are time-accumulated visible and IR histograms used as cloud cover descriptors, the estimation of the radiation budget's sensitivity to cloud variations, monitoring global surface temperature variations using cloud data sets, and an analysis of preliminary SAGE II data on ozone and NO2. O.C.

A88-17039
EARTH SCIENCE MISSIONS FOR THE SPACE STATION
WILLIAM D. CARTER (Globex, Inc., Reston, VA) (COSPAR, International Union of Geological Sciences, UN, et al., Plenary Meeting, 26th, Workshop X and Topical Meeting on Remote Sensing: Earth's Surface and Atmosphere, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 7, no. 3, 1987, p. 101-106. refs

Begining as early as 1994, the NASA Space Station will be operational in low equatorial orbit. It is presently recommended that the Station incorporate as part of its instrument suite a multispectral synthetic aperture imaging radar, which would be primarily used to map cloud-covered regions of the globe, and an imaging spectrometer, which would be similar to the Shuttle Multispectral IR Radiometer. The radar would give emphasis to the study of such transient phenomena as ocean surface roughness and wind shear effects during hurricanes and typhoons; the radiometer would have a 50-km swath width, and 128 bands from 0.4 to 2.5 microns. O.C.

A88-18634*# Tokyo Univ. (Japan).
RESULTS FROM A SERIES OF TETHERED ROCKET EXPERIMENTS
S. SASAKI, K. I. OYAMA, N. KAWASHIMA, Y. WATANABE, T. OBAYASHI (Tokyo, University, Japan) et al. Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, Sept.-Oct. 1987, p. 444-453. refs
(Contract NAGW-235)

This paper reports the results of three tethered rocket experiments conducted as part of a U.S.-Japan joint program under way since 1980. The major purpose of the experiments is to obtain technical and scientific data supporting the figure electrodynamic tethered subsatellite experiments by the Space Shuttle. Vehicle charging due to dc beam emission up to 80 mA in the 150-200 km altitude range was repeatedly measured by both Langmuir and floating probes, and was found to be usually less than 10 V. During the 80 mA emission, clear evidence for the ignition of a beam-plasma discharge was obtained. In a tether deployment experiment, it was found that the tether wire acted as an antenna whose impedance decreased with the extension of the wire both in high-frequency and very low-frequency bands. Substantial rocket charging was observed during periods of electron-beam very low-frequency pulsing. C.D.

A88-19883* State Univ. of New York, Buffalo.
A MODEL-FREE METHOD FOR MASS SPECTROMETER RESPONSE CORRECTION
BARBARA E. SHYKOFF and HARVEY T. SWANSON (New York, State University, Buffalo) Journal of Applied Physiology (ISSN 0161-7567), vol. 63, Nov. 1987, p. 2148-2153. refs
(Contract NASI-16042)

A new method for correction of mass spectrometer output

signals is described. Response-time distortion is reduced independently of any model of mass spectrometer behavior. The delay of the system is found first from the cross-correlation function of a step change and its response. A two-sided time-domain digital correction filter (deconvolution filter) is generated next from the same step response data using a regression procedure. Other data are corrected using the filter and delay. The mean squared error between a step response and a step is reduced considerably more after the use of a deconvolution filter than after the application of a second-order model correction. O2 consumption and CO2 production values calculated from data corrupted by a simulated dynamic process return to near the uncorrupted values after correction. Although a clean step response or the ensemble average of several responses contaminated with noise is needed for the generation of the filter, random noise of magnitude not above 0.5 percent added to the response to be corrected does not impair the correction severely. Author

A88-20036
DYNAMICS AND CONTROL OF THE TETHERED SATELLITE SYSTEM IN THE PRESENCE OF OFFSETS
P. K. LAKSHMANAN, V. J. MODI, and A. K. MISRA (British Columbia, University, Vancouver, Canada) Acta Astronautica (ISSN 0094-5765), vol. 15, Dec. 1987, p. 1053-1057.

A mathematical model for studying the dynamics of the Tethered Satellite System (TSS) is proposed that accounts for a three-dimensional offset of the point of attachment. The system chosen consists of a plate-type Space Station from which a tether supported subsatellite is deployed or retrieved. The mass of the tether as well as the rigid body dynamics of the tether, subsatellite and Space Station are considered. Controllability of the linearized equations is established numerically and the control is achieved through simple velocity feedback using thrusters and momentum wheels. Author

A88-20067
EARTH OBSERVATION FROM THE SPACE STATION
JOHN PLEVIN and DAVID LYNN (SERC, Swindon, England) (British Interplanetary Society, Space '86 , Brighton, England, Sept. 26-28, 1986) British Interplanetary Society, Journal (ISSN 0007-084X), vol. 40, Nov. 1987, p. 505-512.

The NASA Space Station's Polar Platform element will routinely furnish remotely-sensed data. Attention is presently given to the application priorities for the Polar Platform and their associated instrumentation requirements, stressing the importance of data handling and the features of proposals for user-based data centers in the Polar Platform's ground segment. Suggestions are made for the configuration of a British sensor development program whose instruments will complement those furnished by ESA. It is concluded that the Polar Platform's operational success will depend on effective institutional arrangements for both orbital and ground segment operations' management. O.C.

A88-21531* Harvard-Smithsonian Center for Astrophysics, Cambridge, Mass.
RECENT DEVELOPMENTS IN GRAVITY GRADIOMETRY FROM THE SPACE-SHUTTLE-BORNE TETHERED SATELLITE SYSTEM
ENRICO C. LORENZINI, GORDON E. GULLAHORN (Harvard-Smithsonian Center for Astrophysics, Cambridge, MA), and FRANCO FULIGNI (CNR, Istituto di Fisica dello Spazio Interplanetario, Frascati, Italy) Journal of Applied Physics (ISSN 0021-8979), vol. 63, Jan. 1, 1988, p. 216-223. refs
(Contract NAG5-338; NAG5-325)

This paper describes the current development of a noncryogenic gravity gradiometer for future use on board the tethered satellite system (TSS). The paper also proposes a way of testing a single-axis prototype of such an instrument that makes use of the free-fall technique in vacuum. This gravity gradiometer has a design sensitivity of the order of 0.01 EU in 10-s integration time. Because of the small size and light weight, a noncryogenic gravity gradiometer is a valid candidate to fit the limited accommodation capability of the TSS deployed from the Shuttle and maintained, for several days, at an altitude of 120-130 km. This unique capability improves the resolution and accuracy achievable in reconstructing the earth gravity field, in particular at short wavelengths. A preliminary analysis of the dynamics of the TSS satellite indicates the potential of such satellite as a low-altitude research platform for gravity gradiometry. Author

A88-21568
EARTH OBSERVATION AND THE SPACE STATION
DAVID L. CROOM (British National Space Centre, London; SERC, Rutherford Appleton Laboratory, Didcot, England) (Columbus II; Proceedings of the Second Workshop, Hanover, Federal Republic of Germany, June 9-11, 1986) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 7, no. 1-2, 1987, p. 143-147.

The organization, objectives, and preliminary results of U.S. and European planning studies on terrestrial remote sensing from the International Space Station are briefly reviewed. Consideration is given to the NOAA-NASA Earth Observation System program, the UK Columbus Utilization Core Group, the Anglo-French Columbus Polar Platform Utilization Working Group, and the ESA Polar Orbiting Platform Group. A number of specific recommendations by these groups are presented, and the need for broad-based international cooperation on the spacecraft, payload, data-management, and institutional levels of the Columbus Polar Platform program is stressed. T.K.

A88-21658* Virginia Univ., Charlottesville.
FOCUS OF ATTENTION IN SYSTEMS FOR VISUAL MONITORING OF EXPERIMENTS
G. E. BLANK and W. N. MARTIN (Virginia, University, Charlottesville) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 236-243. refs
(Contract NAG5-597)

The problem of designing a computerized experiment monitoring system for use in a space station or elsewhere is examined. It is shown that the essential challenge of such a system - attaining a reasonable expected running time - can be attacked using the concept of focus of attention and by exploiting parallelism. The use of the Contract Net Protocol for the latter purpose is discussed. The use of ideas from information science to help focus a programs's efforts on those computations likely to bring results is addressed, and the incorporation of those ideas into a design in order to aid the system in deciding upon the best course of action is considered. C.D.

A88-22046#
EXPLORER PLATFORM
RANDY F. SIMPSON (Fairchild Space Co., Germantown, MD) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 6 p.
(AIAA PAPER 88-0066)

The Explorer Platform (EP) under development for NASA encompasses the Multimission Modular Spacecraft, which is augmented by a novel Platform Equipment Deck. The 10-year life expectancy of the EP is associated with considerable cost effectiveness by comparison with current systems. The EP possesses such conventional components as a communications and data-handling module, a modular attitude control system, and a power systems module. The EUV Explorer spacecraft, which will be the first to be flown aboard the EP, is designed for the study of objects emitting in the EUV and consists of three scanning telescopes and one spectrometer. O.C.

A88-22083*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OSSA'S TELESCIENCE CONCEPT FOR THE SPACE STATION ERA
JAMES R. WEISS (California Institute of Technology, Jet Propulsion Laboratory, Pasadena; NASA, Communications and Information

Systems Div., Washington, DC) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 4 p.
(AIAA PAPER 88-0120)

NASA's Office of Space Science and Applications has formulated an operational concept, 'telescience', for Space Station-related missions; telescience encompasses teledesign, teleoperations, teleanalysis, and an overall integrating structure that defines and delineates the system's architectural infrastructure and networking for implementation. Attention is here given to the development status of data interchange standards, interoperable networks, automated data-ingest mechanisms and access directories, means to the accessing of heterogeneous data bases, and user-support environments. O.C.

A88-22113#
VAPOR TRANSPORT FURNACE FOR ORGANIC CRYSTALS AND FILMS
FRANCIS C. WESSLING and STEVEN L. NOOJIN (Alabama, University, Huntsville) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 6 p.
(AIAA PAPER 88-0160)

A vapor transport furnace capable of operating on several different experiment carriers on the Space Transportation System (STS) or on Space Station is described. The furnace consists of two concentric aluminum tubes with a vacuum space between them. A quartz ampoule containing the chemicals for crystal growth is placed inside of the inner aluminum tube. Special design considerations allow the furnace to operate at a 413 K interior temperature with a power consumption of less than three watts when operated in a 293 K environment. Gold coatings decrease the radiation heat transfer. A special support mechanism between the two aluminum tubes causes the heat transfer by conduction to be inconsequential. Results of thermal analyses are described herein. The design is versatile enough to allow its use in solution crystal growth, polymer reactions, and other applications in addition to vapor transport crystal growth. Author

A88-22333*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AN OPERATIONS CONCEPT FOR THE SPACE STATION BASED ASTROMETRIC TELESCOPE FACILITY
ROBERT W. JACKSON and MARTHA A. SMITH (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. refs
(AIAA PAPER 88-0447)

The Astrometric Telescope Facility (ATF) will be an orbiting observatory which has been proposed to be attached to the NASA Space Station. The primary scientific objectives of the ATF will be to search for extrasolar planetary systems and to study their characteristics. In addition, the ATF will be able to perform other general astrometric observations of stars within the Milky Way Galaxy. Astrometric Telescope Facility operations from the Space Station will be simple and straightforward compared to other orbiting free-flying telescopes. The astrometric approach to planetary detection, which uses repeated measurements of the same set of target stars over many years, is compatible with simple, repetitive operations of the facility. The support provided by the Space Station and anomaly tolerance features of the ATF design also contribute to the simplicity of the operations concept. Author

A88-22396#
TETHERS IN SPACE - A BROAD PERSPECTIVE
JAMES K. HARRISON AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 6 p. refs
(AIAA PAPER 88-0530)

The concepts being used and efforts underway in the United States and Italy on tether applications are outlined. Applications in the areas of momentum transfer, special positioning of a probe in space, electrodynamics, and gravity generation are emphasized. Prototypes now being tested are examined, and the deployment systems being developed are discussed. C.D.

A88-22397*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
TETHER DYNAMICS SIMULATION WORKSHOP SUMMARY
CHARLES C. RUPP (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 4 p.
(AIAA PAPER 88-0531)

The Tether Dynamics Simulation Workshop focused on the efforts of the Tether Applications Simulation Working Group (TASWG) to catalog various dynamics simulations, document environmental models, and provide a set of verified simulation results. The workshop consisted of reports on these activities and the presentation of papers on current dynamics topics of general interest. This paper documents the work performed at the Workshop and the results and recommendations for further work. Author

A88-22398*# National Aeronautics and Space Administration, Washington, D.C.
TETHER TECHNOLOGY - CONFERENCE SUMMARY
JOHN L. ANDERSON (NASA, Washington, DC) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 7 p. refs
(AIAA PAPER 88-0533)

This paper summarizes the results of a session devoted to tether technology at the Second International Conference on Tethers in Space held in Venice, Italy, on October 4-8, 1987. The approach taken is to provide excerpts from the abstracts and conclusions of the papers presented at the conference. Author

A88-22399#
TETHERS ON STATIONS AND PLATFORMS
DALE A. FESTER (Martin Marietta Space Systems Co., Denver, CO) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 6 p. refs
(AIAA PAPER 88-0534)

Various aspects of the use of tethers on the Space Station and other platforms are examined. Consideration is given to the use of tethers to improve gravity gradient stabilization, provide desired microgravity levels with a tethered elevator, improve docking maneuvers, and allow construction and deployment of solar sails. Special attention is given to the use of electrodynamic tethers for the generation of electrical power for the Space Station. In addition, uses for expendable tethers, tethered waste disposal, the return of Station material, and vehicle deployment/reentry with tethers are discussed together with a sling tether maneuver for orbit transfer. Possible implemetation scenarios are described, and issues which must be addressed in the tether/platform integration are identified. Although tethered systems can significantly increase overall Space Station capability, they are complex and do require careful up-front design to ensure their overall safety and practicality. The paper includes multiple diagrams illustrating uses of tether systems. I.S.

A88-22400*# National Aeronautics and Space Administration, Washington, D.C.
COMMENTS ON THE 'EARLY EXPERIMENTAL VALIDATION' SESSION OF THE SECOND INTERNATIONAL CONFERENCE ON TETHERS IN SPACE
LEONARD A. HARRIS (NASA, Washington, DC) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 7 p. refs
(AIAA PAPER 88-0535)

The paper summarizes the 'early experiment aspects' of the session which focused on the need for low cost, simple flight experiments to verify tether concepts, analysis methods and simulations and to build a data base for future application of tethers. The papers discussed six well thoughtout new space experiments, a modest start toward obtaining the data needed before tether concepts can be realistically expected to be adopted in real designs. Of the ninety-five papers included in the Venice conference, only six new small experiments were discussed. In-space verification of the data base needed to design operational tethers continues to be a step in the future. Author

A88-22485*# Smithsonian Astrophysical Observatory, Cambridge, Mass.
A TELESCOPE FOR HIGH ENERGY GAMMA-RAY MEASUREMENTS IN THE SPACE STATION ERA
DAVID G. KOCH (Smithsonian Astrophysical Observatory, Cambridge, MA), PHILIPPE GORET (CEA, Service d'Astrophysique, Gif-sur-Yvette, France), and MAX NEIN (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 6 p.
(AIAA PAPER 88-0652)

This paper describes the concept of a large gamma-ray imaging telescope system (GRITS) which will provide sufficient sensitivity for the identification of faint objects to be catalogued by the Gamma-Ray Observatory. The technique used in this telescope for the detection of gamma rays is based on the conversion of the incident gamma ray into an electron-positron pair which subsequently produces Cherenkov radiation. The gamma ray is identified by a unique signature based on a sequence of time-delayed coincidence events. The GRITS telescope will use the extended Shuttle external tank, ET, as the pressure vessel necessary for the gas-Cherenkov process. Astronauts from the Shuttle or the Space Station performing EVA will convert ET to an autonomous spacecraft and install the telescope inside the ET. I.S.

A88-22513#
TETHER SATELLITE POTENTIAL FOR RAREFIED GAS AERODYNAMIC RESEARCH
F. C. HURLBUT (California, University, Berkeley) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. refs
(AIAA PAPER 88-0687)

Applications of the tether satellite in aerodynamic research under conditions of low density hypervelocity flow are described. The satellite is envisioned as a sphere nose, slab-sided cylinder with variably swept wing, tethered to the Shuttle Orbiter and deployed to altitudes of about 95 km and above. Suggested experiments reflect requirements for new understanding of low density flows and include the direct measurement of normal and tangential stress on representative aerospace surfaces, the measurements of vehicle lift, drag and pitching moment, ambient gas density and composition, surface temperatures, and wall tap and impact probe behavior. Also suggested are measurements of gas densities above the wing surfaces and on or near the stagnation line using electron beam fluorescence methods and, where applicable, free molecule orifice probes. Experiments proposed are consistent with the objectives of the STARFAC proposal and may be implemented without significant development of new technology. Author

A88-22514*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DOWNWARD-DEPLOYED TETHERED PLATFORMS FOR HIGH ENTHALPY AEROTHERMODYNAMIC RESEARCH
GEORGE M. WOOD, PAUL M. SIEMERS (NASA, Langley Research Center, Hampton, VA), R. KENNETH SQUIRES, HENRY WOLF (Analytical Mechanics Associates, Inc., Hampton, VA), GIOVANNI M. CARLOMAGNO (Napoli, Universita, Naples, Italy) et al. AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p. refs
(AIAA PAPER 88-0688)

The data on aerothermodynamic and aerodynamic interactions at altitudes above 50 km is extremely limited because of the relative inaccessibility of the region to research vehicles of any sort. This paper addresses the practicability of using downward deployed satellites tethered to an orbiting host vehicle in order to obtain steady-state data in the upper reaches of the region above 80 or 90 km. Author

A88-22515*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
APPLICATIONS OF TETHERED SATELLITES TO SOME PROBLEMS OF TERRESTRIAL PHYSICS
WILLIAM J. WEBSTER, JR. (NASA, Goddard Space Flight Center, Greenbelt, MD) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 7 p. refs
(AIAA PAPER 88-0689)

An evaluation is made of the applicability of tethered satellites to geomagnetic field and low altitude magnetospheric/ionospheric plasma investigations. Geomagnetic field observations from tethered satellites with gradiometers promise higher field measurement accuracy and the separation of current effects; plasma observations are important in understanding such processes as the deposition of magnetospheric energy into the upper atmosphere, and the influence of magnetospheric current distribution on this process. The unusual requirements that emerge for attitude knowledge and dynamic isolation in the satellite's instrumentation are discussed. O.C.

A88-22516*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
THE TETHERED SATELLITE ELECTRODYNAMICS EXPERIMENT PROJECT
JOHN M. PRICE (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 16 p.
(AIAA PAPER 88-0690)

NASA and Italy's PSN have undertaken the Tethered Satellite Electrodynamics Experiment, in which two tethered bodies will be equipped with data-collecting scientific instruments, as the first stage of the development of the Tethered Satellite System that can be deployed by the Space Shuttle. The experiment will give attention to the electromagnetic interaction between the satellite/tether/orbiter system and the ambient space plasma, and should demonstrate the operation of both satellite- and Shuttle-borne electrodynamic instruments with a conductive tether. O.C.

A88-23924
THE STRUCTURE OF ULF WAVES PRODUCED BY A TETHERED SATELLITE SYSTEM
A. N. WRIGHT (Queen Mary College, London, England) Astronomy and Astrophysics (ISSN 0004-6361), vol. 186, no. 1-2, Nov. 1987, p. 354-358. refs

The Alfven waves produced by a tethered satellite system (TSS) are modeled within the MHD approximation. Expressions for the current, velocity, electric, and magnetic fields are derived using the general formalism given by Wright and Southwood (1987) to describe stationary Alfvenic structures. The current closure in the Alfven wave is found to have some novel features. The subsidiary current system that flows in a plane perpendicular to the wave structure has a quadrupolar character, in contrast to the dipolar magnetic field and flow perturbations. The topology of the perpendicular current has not been understood in previous TSS models. The worked example that is presented compliments the work of Wright and Southwood, who anticipated that the polar order of the perpendicular currents would be twice that of the magnetic field and plasma flow perturbations. Author

A88-24454
THE INCREDIBLY VERSATILE SPACE TETHER
BOB JAQUES Space Marketing (ISSN 0258-4212), Winter 1987, p. 208-210.

A simple space tether connects two orbiting masses by a space environment-resistant cable; these masses are forced to orbit at the angular velocity of the system's center-of-gravity. Since the speed of the upper mass is greater than it would normally be if the mass were untethered and orbiting at the same altitude, a greater centrifugal force than gravitational force is experienced by it. The reverse is true for the lower mass, which experiences a greater gravitational than centrifugal force. Attention is presently given to the electrodynamic, transportation, and pure/applied scientific experimentation applications of the space tether concept. O.C.

A88-25890* Harvard-Smithsonian Center for Astrophysics, Cambridge, Mass.
ALFVEN WAVES FROM AN ELECTRODYNAMIC TETHERED SATELLITE SYSTEM
ROBERT D. ESTES (Harvard-Smithsonian Center for Astrophysics, Cambridge, MA) Journal of Geophysical Research (ISSN 0148-0227), vol. 93, Feb. 1, 1988, p. 945-956. refs
(Contract NAG8-551)

The ionospheric plasma currents associated with the operation of an orbiting, constant current electrodynamic tethered satellite system are calculated using linear cold plasma theory and a tethered system current distribution model that takes into account the peculiar dumbbell shape of the system. The field line current calculations show plasma sheet currents at each end of the tethered system whose structure is roughly that of the Alfven wings. The disturbance caused by the moving tethered system extends behind its dimensions along the line of sight. The form of the wings alters as they travel away from the system. The front boundary becomes sharper while the ripples in J(z) in the wake extend to greater distances with larger amplitude. The wave impedance is calculated for a wide range of system dimension values. The expression is in sharp disagreement with a recently published result by Dobrowolny and Veltri (1986). C.D.

A88-26687
CONSTRUCTION OF A FULL SOLUTION FOR AN INTEGRABLE CASE OF THE PROBLEM OF THE MOTION OF TWO COUPLED BODIES [K POSTROENIIU POLNOGO RESHENIIA V ODNOM SLUCHAE INTEGRIRUEMOSTI ZADACHI O DVIZHENII DVUKH SVIAZANNYKH TEL]
M. E. LESINA (Donetskii Politekhnicheskii Institut, Donetsk, Ukrainian SSR) Mekhanika Tverdogo Tela (ISSN 0321-1975), no. 19, 1987, p. 54-57. In Russian. refs

The system considered here consists of two bodies whose mass distribution is similar to that of Lagrange gyroscopes and which are coupled at points of their axes by an ideal spherical joint characterized by a moment acting to superpose the axes. The system, which models double-rotation satellites, moves in space by inertia. A full solution to the problem is obtained for a case of integrability using the axoid method. V.L.

A88-26688
CONSTRUCTION OF A FULL SOLUTION TO THE PROBLEM OF THE RELATIVE MOTION OF A SYSTEM OF TWO BODIES [K POSTROENIIU POLNOGO RESHENIIA ZADACHI OB OTNOSITEL'NOM DVIZHENII SISTEMY DVUKH TEL]
M. E. LESINA (Donetskii Politekhnicheskii Institut, Donetsk, Ukrainian SSR) Mekhanika Tverdogo Tela (ISSN 0321-1975), no. 19, 1987, p. 58-68. In Russian. refs

The paper is concerned with the relative motion of two bodies whose mass distribution corresponds to the structure of Lagrange gyroscopes and which are connected by a spherical joint with a moment acting to superpose the axes, this moment being dependent on the angle between the axes. The motion of the bodies is analyzed relative to the natural axes along the path of the spherical joint. Hodograph equations are obtained for the angular velocity of such motion. V.L.

A88-27535#
THE SPACEBUS PLATFORMS
M. CHOGNOT (Aerospatiale, Cannes, France) and A. JABLONSKI (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) IN: AIAA International Communication Satellite Systems Conference, 12th, Arlington, VA, Mar. 13-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 72-85.
(AIAA PAPER 88-0775)

On the basis of their long lasting cooperation in space activities, Aerospatiale and MBB have signed in 1983 a cooperative agreement in the field of geostationary communication satellites. They have developed a family of platforms, named Spacebus, with the goal to rationalize their development effort and to offer to any customer an optimized product. Allocation of system and subsystem responsibilities has been made, depending on various criteria, and development efforts focussed, for each company, in dedicated fields. The paper presents the performance of the various members of the Spacebus family (Spacebus 100, Spacebus 300), describes the highlights of platform subsystems, and presents several examples of applications (Direct Broadcasting Satellites and Telecommunication Satellites such as TV-Sat, TDF, Tele-X, Eutelsat II). It ends with indication of future developments aiming at improvement of the performance of the existing products and extending the range of applications to future, more demanding missions. Author

A88-27781#
ABSORPTIVE TETHERS - A FIRST TEST IN SPACE
W. J. OCKELS (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) ESA Journal (ISSN 0379-2285), vol. 11, no. 3, 1987, p. 355-358.

This paper presents a new concept for an absorptive tether (patent application in process) to be used for spaceborne proximity operations and positioning in general. The passive means by which friction is introduced facilitates certain operations in space, and makes them safer. An absorptive tether of the type described was flown on the German Spacelab D-1 mission in November 1985. Author

A88-27838
SWATH ALTIMETRY OF OCEANS AND TERRAIN
C. G. RAPLEY (London, University College, Dorking, England) and H. D. GRIFFITHS (University College, London, England) (COSPAR, WMO, URSI, et al., Plenary Meeting, 26th, Symposium 3, Workshop V, and Topical Meeting A2 on Remote Sensing from Space, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 7, no. 11, 1987, p. 319-322. refs
(Contract ESA-6001/84/NL/BI)

Satellite radar altimeters have demonstrated a wide range of scientific capabilities over oceans and ice, and have considerable potential over land and inland water. However, the universal adoption of the single-beam, pulse-limited mode of operation limits the spatial and temporal sampling achievable and makes the generation of surface elevation maps critically dependent on the accuracy of the satellite orbit reconstruction. Also, over topographic surfaces, the data can be difficult, sometimes impossible, to interpret. With the advent of the Columbus polar platform, previous limitations on the size and complexity of space instruments will not apply. What types of swath altimeter might take advantage of this possibility are considered, and it is concluded that both multifeed, large antenna instruments and an interferometric design could provide valuable advances. Ultimately, a scanning beam, phased array instrument could provide full global coverage with high spatial resolution. Author

A88-29974
GEOSTATIONARY TETHER SATELLITE SYSTEM AND ITS APPLICATION TO COMMUNICATIONS SYSTEMS
TETSUO YASAKA (Nippon Telegraph and Telephone Public Corp., Radio Communication Systems Laboratories, Yokosuka, Japan) and TAKESHI HATSUDA (Hokkaido Institute of Technology, Sapporo, Japan) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. 24, Jan. 1988, p. 68-75. refs

The geostationary tether satellite system expands the geostationary orbit resource from a one-dimensional arc into a two-dimensional disk. The tethered satellites, each several thousand kilometers apart and aligned along the local vertical, are stabilized at the altitude of the geosynchronous orbital speed. When this system is applied to communications systems, it is estimated that the number of satellites can be increased as much as 13 times and the communication capacity can be increased more than 17 times, compared with a conventional geostationary satellite orbit system. Author

N88-10079# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
STUDY OF A PAYLOAD FOR COLUMBUS POLAR PLATFORM EARTH OBSERVATION DEMONSTRATION MISSION, EXECUTIVE SUMMARY
A. HAMFSFAHR, M. LANGEMANN, J. E. CHARLTON, R. CORTINOVIS, F. G. SAWYER, P. HOLLIER (MATRA Espace, Toulouse, France), and N. SKOU Paris, France ESA Sep. 1986 31 p
(Contract ESTEC-6612/86-NL-JS)
(ESA-CR(P)-2412; ETN-87-90548) Avail: NTIS HC A03/MF A01

A set of six core instruments was defined for the IOC model payload of the Columbus Morning Polar Platform. The synthetic aperture radar, the optical imager, the multifrequency imaging microwave radiometer, and the wind scatterometer were studied. The definition status of the instruments with respect to their basic electrical and mechanical design features, performance, resource requirements, mutual compatibilities, and their adaptability on the Columbus platform is summarized. ESA

N88-10081# European Space Agency, Paris (France). Space Science Dept.
REPORT ON THE SCIENTIFIC SATELLITES OF THE EUROPEAN SPACE AGENCY
W. R. BURKE, ed., BRIAN G. TAYLOR, ed., U. O. FRISK, R. GRARD, P. JAKOBSEN, M. KESSLER, J.-P. LEBRETON, R. MARSDEN, H. OLTHOF, A. PEACOCK (European Space Agency, European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) et al. May 1987 155 p Original contains color illustrations
(ESA-SP-1090; ISSN-0379-6566; ETN-87-90868) Avail: NTIS HC A08/MF A01

The status of the ISEE, IUE, EXOSAT, Spacelab, and Giotto missions is described. The Ulysses, Hubble Space Telescope, HIPPARCOS, ISO, EURECA, and Cluster/SOHO projects are discussed. The submillimeter mission, high throughput X-ray spectroscopy mission, and the comet nucleus sample return mission are introduced. The Lyman, Quasat, and Cassini studies are summarized. The GRASP gamma ray astronomy mission, the Vesta Mars mission, and the Giotto extended mission are reviewed. ESA

N88-10086*# General Electric Co., Philadelphia, Pa.
SPACE STATION PLATFORMS
DANIEL F. REID *In* NASA-Lewis Research Center, Spacecraft 2000 p 7-10 Jul. 1986
Avail: NTIS HC A11/MF A01 CSCL 22B

The international space station platforms are the first step toward routine application of special features. Growth capabilities and expansion of technology are examined. Resource requirements, servicing, modularity, and autonomous operations are outlined. B.G.

N88-10625# Erlangen-Nuremberg Univ. (West Germany). Inst. fuer Physik.
ISIS: IMAGING SPECKLE INTERFEREOMETER IN SPACE
GERD WEIGELT *In* ESA, ESA Workshop on Optical Interferometry in Space p 69-72 Aug. 1987
Avail: NTIS HC A11/MF A01

The construction of a large multimirror interferometer in space is proposed. Resolution of 0.001 arcsec at 100 nm is feasible with a 20 m baseline. A shuttle launched 14 m linear array, a 2 dimensional, deployable 20 m array, and arrays of 6 to 20 free-flying telescopes with baselines up to 40 km and resolution of 0.000001 arcsec at 200 nm are possible. At short UV wavelengths a multimirror interferometer will produce speckle interferograms caused by misalignment of the interferometer. From the speckle interferograms true images can be reconstructed by the phase-closure method (if the exit pupil is a nonredundant array) or by speckle masking (for general pupils). In the case of bright objects the phase-closure method yields higher signal-to-noise ratio than speckle masking. In the case of faint objects speckle masking yields higher signal-to-noise ratio than the phase-closure method. The limiting magnitude of optical long-baseline interferometry in space is 24 or fainter. ESA

N88-10628# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
SPACE STATION BASED INTERFEROMETRY
H. OLTHOF *In its* ESA Workshop on Optical Interferometry in Space p 93-102 Aug. 1987
Avail: NTIS HC A11/MF A01

Applications of ESA programs to space interferometry are summarized. Inflatable, space rigidized technology; tethered spinning concepts; range measurement; laser Doppler radar; fine pointing elements for optical space communication; electric propulsion; and solid state accelerometers are discussed. ESA

N88-10747*# National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.
SOLAR-TERRESTRIAL RESEARCH IN THE SPACE STATION ERA Abstract Only
CHARLES R. CHAPPELL *In* Alabama Univ., Huntsville. STIP Symposium on Physical Interpretation of Solar/Interplanetary and Cometary Intervals p 44 14 Sep. 1987
Avail: NTIS HC A04/MF A01 CSCL 03B

Because of the immense size of the solar-terrestrial system and its tightly-coupled physical nature, its study requires a carefully planned and coordinated approach using a variety of observational techniques. Of fundamental importance is the simultaneous measurement of the varying Sun, the solar wind, and the Earth's magnetosphere and atmosphere. These multiple measurements require a multi-spacecraft approach with both remote sensing of the Sun and atmosphere and in-situ measurements of the solar wind and magnetosphere. The decade of the 1990s will bring an opportunity to carry out the simultaneous set of measurements using a combination of instruments on missions such as the International Solar Terrestrial Physics Program, the GOES satellites, and the Space Station. For the first time it will be possible to determine solar variability and to sample the response of the solar wind and geospace portion of the environment in a thorough way. The potential opportunities for solar-terrestrial studies during the coming era of the Space Station are disclosed. Author

N88-10828*# Ball Aerospace Systems Div., Boulder, Colo.
PHASE 3 STUDY OF SELECTED TETHER APPLICATIONS IN SPACE. VOLUME 2: STUDY RESULTS Final Report
Dec. 1986 196 p
(Contract NAS8-36617)
(NASA-CR-179186; NAS 1.26:179186; DPD-665-VOL-2; DR-4-VOL-2) Avail: NTIS HC A09/MF A01 CSCL 22B

Engineering designs were developed relative to a tethered launch assist from the Shuttle for payloads up to 10,000 kg mass and the tethering of a 15,000 kg science platform from the space station. These designs are used for a cost benefit analysis which assesses the feasibility of using such systems as a practical alternative to what would otherwise be accomplished by conventional means. The term conventional as related to both these applications is intended to apply to the use of some form(s) of chemical propulsion system. B.G.

N88-11481*# Honeywell, Inc., Clearwater, Fla. Space and Strategic Avionics Div.
PINHOLE OCCULTER EXPERIMENT Final Report
JEFF RING and JOHN PFLUG 27 Feb. 1987 141 p
(Contract NAS8-36101)
(NASA-CR-179206; NAS 1.26:179206) Avail: NTIS HC A07/MF A01 CSCL 20F

Viewgraphs and charts from a briefing summarize the accomplishments, results, conclusions, and recommendations of a feasibility study using the Pinhole Occulter Facility (POF). Accomplishments for 1986 include: (1) improved IPS Gimbal Model; (2) improved Crew Motion Disturbance Model; (3) use of existing shuttle on-orbit simulation to study the effects of orbiter attitude

deadband size on POF performance; (4) increased understanding of maximum performance expected from current actuator/sensor set; (5) use of TREETOPS nonlinear time domain program to obtain system dynamics describing the complex multibody flexible structures; (6) use of HONEY-X design tool to design and evaluate multivariable compensator for stability, robustness, and performance; (7) application of state-of-the-art compensator design methodology Linear Quadratic Gaussian/Loop Transfer Recovery (LQG/LTR); and (8) examination of tolerance required on knowledge of the POF boom flexible mode frequencies to insure stability, using structure uncertainty analysis. J.P.B.

N88-11737*# Ball Aerospace Systems Div., Boulder, Colo.
ELECTRODYNAMIC TETHER SYSTEM STUDY Final Report
Sep. 1987 75 p
(Contract NAS9-17666)
(NASA-CR-172024; NAS 1.26:172024) Avail: NTIS HC A04/MF A01 CSCL 22B

The purpose of this program is to define an Electrodynamic Tether System (ETS) that could be erected from the space station and/or platforms to function as an energy storage device. A schematic representation of the ETS concept mounted on the space station is presented. In addition to the hardware design and configuration efforts, studies are also documented involving simulations of the Earth's magnetic fields and the effects this has on overall system efficiency calculations. Also discussed are some preliminary computer simulations of orbit perturbations caused by the cyclic/night operations of the ETS. System cost estimates, an outline for future development testing for the ETS system, and conclusions and recommendations are also provided. B.G.

N88-12131# European Space Agency, Paris (France).
COMMERCIAL OPPORTUNITIES FOR REMOTE SENSING WITH POLAR PLATFORMS
T. D. GUYENNE, comp. and J. J. HUNT, comp. Apr. 1987 75 p Workshop held in Frascati, Italy, 4-5 Sep. 1986
(ESA-SP-269; ISSN-079-6566; ETN-87-90866) Avail: NTIS HC A05/MF A01

Commercial use of the Columbus Polar Platforms; payload configurations and serviceability; interoperability and integration of data relay satellite systems; legal protection of Polar Platform users; confidentiality of data; market potential for commercial remote sensing; commercial perspectives of an imaging spectrometer program; remote sensing user requirements; an advanced microwave imaging radiometer; and an X-band SAR for a European remote sensing payload were discussed. ESA

N88-12133# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Directorate of Earth Observation and Microgravity.
PAYLOAD CONFIGURATIONS AND SERVICEABILITY
N. DEVILLIERS *In its* Commercial Opportunities for Remote Sensing with Polar Platforms p 11-16 Apr. 1987
Avail: NTIS HC A05/MF A01

A Columbus Polar Platform scenario for Earth observations is outlined. It features: 2 platforms in coordinated Sun-synchronous orbits at an altitude of 800 km: 1 in a morning orbit, with a descending node between 09.30 and 10.30, and the other in an afternoon orbit, with an ascending node between 13.00 and 14.30; a multidisciplinary payload divided between the platforms with 2.4 tons per platform and the capability for further growth; and servicing every 3 yr for maintaining the capabilities, adding new payloads, and upgrading payloads. Data rates up to several hundred megabits/sec are compatible with: direct downlinking, and the proposed European Data Relay Satellite System. Lower data rates generated globally are compatible with on-board recording techniques. The methods for acquiring the data on the ground are compatible with the delivery time requirements for the different applications. ESA

N88-12142# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
X-BAND SAR FOR A EUROPEAN REMOTE SENSING PAYLOAD
H.-M. BRAUN and W. KRIEGL *In* ESA, Commercial Opportunities for Remote Sensing with Polar Platforms p 67-69 Apr. 1987
Avail: NTIS HC A05/MF A01

The conceptual layout of an X-band SAR for the Columbus Polar Platform is presented. Together with an upgraded version of the ERS-1 SAR in C-band, which could be also developed for the Polar Platform, it could provide dual frequency/dual polarization SAR images from space. The X-SAR is primarily a replica of the Shuttle X-SAR to be launched together with SIR-C. ESA

N88-12501*# TRW Defense and Space Systems Group, Redondo Beach, Calif.
STUDY OF PLASMA MOTOR GENERATOR (PMG) TETHER SYSTEM FOR ORBIT REBOOST Final Report
Sep. 1987 54 p
(Contract NAS9-17751)
(NASA-CR-172016; NAS 1.26:172016) Avail: NTIS HC A04/MF A01 CSCL 22A

Detailed designs were produced for a 2 kW plasma motor generator tether system based largely on existing hardware and hardware designs. Specifically, the hollow cathode design and electronics are derived from ion propulsion equipment. A prototype tether was constructed and will be tested for deployment, strength, resistance to breakage and abrasion and electrical properties. In addition, laboratory development models of the electronics will be used to operate two plasma motor generator hollow cathode assemblies with this tether to verify electrical performance parameters for the complete system. Results show that a low cost demonstration of a plasma motor generator tether system appears to be feasible by the middle of the 1990s. Author

N88-12533*# Smithsonian Astrophysical Observatory, Cambridge, Mass.
ANALYTICAL INVESTIGATION OF THE DYNAMICS OF TETHERED CONSTELLATIONS IN EARTH ORBIT (PHASE 2) Quarterly Report No. 10, 1 Jul. - 30 Sep. 1987
ENRICO C. LORENZINI Oct. 1987 64 p
(Contract NAS8-36606)
(NASA-CR-179218; NAS 1.26:179218) Avail: NTIS HC A04/MF A01 CSCL 22B

Simulation of two short distance crawling maneuvers of the elevator both with and without environmental perturbations acting upon the system is discussed. These simulation runs were performed in order to provide results useful for the interpretation of the data from the tests, on the ground, of a scaled down engineering model of the elevator. In these simulation runs the elevator crawls along the tether in accordance to the developed mirror image motion control law (MIMCL). Results from the simulation of the 4 km long maneuver run were compared to those obtained by adopting the modified hyperbolic tangent control law (MHTCL). A preprocessor was developed for setting up the initial conditions of a tethered system with L platforms, M longitudinal dampers, and N lumped masses (platforms plus tether beads). A short test run of the 4-platform system with 3 longitudinal dampers and 10 lumped mass without any perturbation acting upon the system is illustrated. In support of the Tether Applications Working Group, SAO is preparing a catalog of tether simulations, has prepared a set of simulator test cases, obtained results from SKYHOOK, and solicited results from simulators at other institutions, and prepared a paper on a specific analytic solution. B.G.

N88-13380# Consiglio Nazionale delle Ricerche, Frascati (Italy). Ist. di Fisica dello Spazio Interplanetario.
RETE EXPERIMENT ASSEMBLY, INTEGRATION, AND VERIFICATION (AIV) ACTIVITIES
U. GUIDONI and M. CANDIDI May 1987 64 p
(IFSI-87-6; ETN-88-91293) Avail: NTIS HC A04/MF A01

The hardware configurations for testing the Research on

Electrodynamic Tether Effects experiment at satellite level, and the test sequences adopted at different test levels are outlined. The mechanical and electrical ground support equipment is described. ESA

N88-14113*# Lockheed-Georgia Co., Marietta.
CARBON DIOXIDE OBSERVATIONAL PLATFORM SYSTEM (CO-OPS) FEASIBILITY STUDY
D. L. BOUQUET, D. W. HALL, and R. P. MCELVEEN Dec. 1987 209 p
(Contract NAS8-36600)
(NASA-CR-179225; NAS 1.26:179225) Avail: NTIS HC A10/MF A01 CSCL 22B

The Carbon Dioxide Observational Platform System (CO-OPS) is a near-space, geostationary, multi-user, unmanned microwave powered monitoring platform system. This systems engineering feasibility study addressed identified existing requirements such as: carbon dioxide observational data requirements, communications requirements, and eye-in-the-sky requirements of other groups like the Defense Department, the Forestry Service, and the Coast Guard. In addition, potential applications in: earth system science, space system sciences, and test and verification (satellite sensors and data management techniques) were considered. The eleven month effort is summarized. Past work and methods of gathering the required observational data were assessed and rough-order-of magnitude cost estimates have shown the CO-OPS system to be most cost effective (less than $30 million within a 10 year lifetime). It was also concluded that there are no technical, schedule, or obstacles that would prevent achieving the objectives of the total 5-year CO-OPS program.
Author

N88-14114*# Lockheed-Georgia Co., Marietta.
FEASIBILITY STUDY OF A CARBON DIOXIDE OBSERVATIONAL PLATFORM SYSTEM. VOLUME 2: PROGRAMMATICS
D. L. BOUQUET, D. W. HALL, and R. P. MCELVEEN Dec. 1986 15 p
(Contract NAS8-36600)
(NASA-CR-180404; NAS 1.26:180404) Avail: NTIS HC A03/MF A01 CSCL 22B

The Carbon Dioxide Observational Platform System (CO-OPS) Work Breakdown Structure (WBS) elements are defined. The cost estimates were derived during the parametric analyses conducted for the pre-phase A CO-OPS study. The methodology presented is very preliminary but is adequate for the economic analysis appropriate to (the conceptual) level of design. Costs are presented for ground power, data communications package, system engineering, operations, maintenance, and facilities. Also presented is the total program funding schedule. B.G.

N88-14123*# General Research Corp., McLean, Va. Space Systems Operations.
TETHERS IN SPACE HANDBOOK
T. G. REESE, W. A. BARACAT, and C. L. BUTNER Aug. 1986 266 p
(Contract NASW-3921)
(NASA-CR-181371; NAS 1.26:181371) Avail: NTIS HC A12/MF A01 CSCL 22B

The handbook provides a list and description of ongoing tether programs. This includes the joint U.S.-Italy demonstration project, and individual U.S. and Italian studies and demonstration programs. An overview of the current activity level and areas of emphasis in this emerging field is provided. The fundamental physical principles behind the proposed tether applications are addressed. Four basic concepts of gravity gradient, rotation, momentum exchange, and electrodynamics are discussed. Information extracted from literature, which supplements and enhances the tether applications is also presented. A bibliography is appended. B.G.

N88-14336# Rome Univ. (Italy). Dipartimento di Fisica.
ASTROMAG: A PARTICLE SPECTROMETER FOR THE SPACE STATION
G. AURIEMMA 30 Apr. 1987 16 p Presented at the 3rd Pisa Meeting on Advanced Detectors, Castiglione della Pescaia, Italy, 2-7 Jun. 1986
(PREPRINT-557; ETN-88-91270) Avail: NTIS HC A03/MF A01

The use of a large superconducting magnet (Astromag) on the Columbus Space Station to study charged particles of nonsolar origin is discussed. Astromag can be used to measure the spectra of antiprotons and positons; search for antihelium; determine chemical composition in the TeV range; and measure the isotopic composition of cosmic ray nuclei. A configuration using one end of the magnet for a matter antimatter spectrometer and the other for a cosmic ray isotope spectrometer is proposed. ESA

N88-15354*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
MICROGRAVITY PARTICLE RESEARCH ON THE SPACE STATION
STEVEN W. SQUYRES, ed., CHRISTOPHER P. MCKAY, ed., and DEBORAH E. SCHWARTZ, ed. Dec. 1987 48 p Workshop held in Moffett Field, Calif., 22-24 Aug. 1985
(NASA-CP-2496; A-87261; NAS 1.55:2496) Avail: NTIS HC A03/MF A01 CSCL 06B

Science questions that could be addressed by a Space Station Microgravity Particle Research Facility for studying small suspended particles were discussed. Characteristics of such a facility were determined. Disciplines covered include astrophysics and the solar nebula, planetary science, atmospheric science, exobiology and life science, and physics and chemistry.

N88-15355*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ASTROPHYSICS AND THE SOLAR NEBULA
JOSEPH NUTH, WALTER DULEY, JOHN GOEBEL, J. MAYO GREENBERG, JOHN KERRIDGE, DOUGLAS LIN, IAN MACKINNON, FRANS RIETMEIJER, JOHN STEPHENS, and MARTIN TOMASKO (Arizona Univ., Tucson.) *In its* Microgravity Particle Research on the Space Station p 3-9 Dec. 1987
Avail: NTIS HC A03/MF A01 CSCL 22A

The following types of experiments for a proposed Space Station Microgravity Particle Research Facility are described: (1) nucleation of refractory vapors at low pressure/high temperature; (2) coagulation of refractory grains; (3) optical properties of refractory grains; (4) mantle growth on refractory cores; (5) coagulation of core-mantle grains; (6) optical properties of core-mantle grains; (7) lightning strokes in the primitive solar nebula; and (8) separation of dust from a grain/gas mixture that interacts with a meter-sized planetesimal to determine if accretion occurs. The required capabilities and desired hardware for the facility are detailed.
J.P.B.

N88-15358*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
EXOBIOLOGY AND LIFE SCIENCE
C. P. MCKAY *In its* Microgravity Particle Research on the Space Station p 25-27 Dec. 1987
Avail: NTIS HC A03/MF A01 CSCL 06B

The following types of experiments for a proposed Space Station Microgravity Particle Research Facility are described: (1) biogenic elements in the interstellar medium; (2) organic material in the solar nebula; (3) volatiles in comets and icy planetesimals; (4) pre-biotic atmospheric chemistry; (5) analysis of cosmic dust particles; and (6) microbial exposure. The required capabilities and desired hardware for the facility are detailed. J.P.B.

N88-15359*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
PHYSICS AND CHEMISTRY
MARTIN MOSKOVITS, LOU ALLAMANDOLA, CHRISTOPHER BECKER, FRIEDEMANN FREUND, M. FREUND, P. HAFF, JILL TARTER, OTIS WALTON, DAVID WEITZ, and BRAD WERNER (California Inst. of Tech., Pasadena.) *In its* Microgravity Particle Research on the Space Station p 29-34 Dec. 1987
Avail: NTIS HC A03/MF A01 CSCL 20C

The following types of experiments for a proposed Space Station Microgravity Particle Research Facility are described: (1) rheology of assemblies of inelastic, frictional particles; (2) grain dynamics in zero gravity; (3) properties of tenuous fractal aggregates; (4) orientation of weakly ferroelectric dust grains; (5) supersonic nozzle beam; and (6) some astrophysical cluster experiments. The required capabilities and desired hardware for the facility are detailed.
J.P.B.

N88-15603*# Rice Univ., Houston, Tex. Dept. of Physics.
SOME CONSIDERATIONS ON MEASURING THE NEWTONIAN GRAVITATIONAL CONSTANT G IN AN ORBITING LABORATORY
STEPHEN D. BAKER *In* NASA. Marshall Space Flight Center, Research Reports: 1987 NASA/ASEE Summer Faculty Fellowship Program 7 p Nov. 1987
Avail: NTIS HC A99/MF E03 CSCL 08G

No fundamental reason has been identified for rejecting the notion of measuring the Newtonian gravitational constant G by observing an artificial binary in a near-Earth orbiting laboratory.
Author

N88-15620*# Alabama Univ., Huntsville. Dept. of Chemistry.
USE OF HYDROPHILIC POLYMER COATINGS FOR CONTROL OF ELECTROOSMOSIS AND PROTEIN ADSORPTION
J. MILTON HARRIS *In* NASA. Marshall Space Flight Center, Research Reports: 1987 NASA/ASEE Summer Faculty Fellowship Program 8 p Nov. 1987
Avail: NTIS HC A99/MF E03 CSCL 11B

The purpose of this project was to examine the utility of polyethylene glycol (PEG) and dextran coatings for control of electroosmosis and protein adsorption; electroosmosis is an important, deleterious process affecting electrophoretic separations, and protein adsorption is a factor which needs to be controlled during protein crystal growth to avoid multiple nucleation sites. Performance of the project required use of X-ray photoelectron spectroscopy to refine previously developed synthetic methods. The results of this spectroscopic examination are reported. Measurements of electroosmotic mobility of charged particles in appropriately coated capillaries reveals that a new, one-step route to coating capillaries gives a surface in which electroosmosis is dramatically reduced. Similarly, both PEG and dextran coatings were shown by protein adsorption measurements to be highly effective at reducing protein adsorption on solid surfaces. These results should have impact on future low-g electrophoretic and protein crystal growth experiments. Author

N88-15631*# Tri-State Univ., Angola, Ind. Dept. of Mechanical and Aerospace Engineering.
TETHER ELEVATOR CRAWLER SYSTEMS (TECS)
FRANK R. SWENSON *In* NASA. Marshall Space Flight Center, Research Reports: 1987 NASA/ASEE Summer Faculty Fellowship Program 23 p Nov. 1987
Avail: NTIS HC A99/MF E03 CSCL 22B

One of the needs of the experimenters on the space station is access to steady and controlled-variation microgravity environments. A method of providing these environments is to place the experiment on a tether attached to the space station. This provides a high degree of isolation from structural oscillations and vibrations. Crawlers can move these experiments along the tethers to preferred locations, much like an elevator. This report describes the motion control laws developed for these crawlers and the testing of laboratory models of these tether elevator crawlers.
Author

N88-15822# Consiglio Nazionale delle Ricerche, Frascati (Italy). Ist. di Fisica dello Spazio Interplanetario.
LABORATORY SIMULATION OF THE ELECTRODYNAMIC INTERACTIONS OF A TETHERED SATELLITE WITH AN IONOSPHERIC PLASMA
C. BONIFAZI, J. P. LEBRETON, G. VANNARONI, C. COSMOVICI, R. DEBRIE, M. HAMELIN, L. POMATHIOD, and H. ARENDS (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) Feb. 1986 28 p Presented at the Electrodynamic Panel of Applications of Tethers in Space Workshop, Venice, Italy, 15-17 Oct. 1985 (IFSI-86-3; ETN-88-91278) Avail: NTIS HC A03/MF A01

A plasma chamber was used to investigate the I-V characteristics of a conductive spherical body (10 cm diameter) in a plasma environment. The influence of a transversal magnetic field at 0.6 and 1.2 G on the sheath potential profile and current collection was investigated. Floating potential profiles were measured at 16 different radial distances from the test body up to 9 body radii in 8 different angular positions. The test body potential could be increased in the range from -200 V up to +100 V. Results confirm a decrease of electron current collection for increasing magnetic field.
ESA

N88-16268# Bergen Univ. (Norway).
AURIO: A PROPOSAL FOR FLYING AURORAL IMAGING OBSERVATORY ON THE POLAR PLATFORM IN THE SPACE STATION/COLUMBUS PROGRAM
J. STADSNES, K. AARSNES, C. D. ANGER, J. BJORDAL, A. BREKKE, D. BRYANT, K. BROENSTAD, J. CARTER, C. CHALONER, L. L. COGGER (Calgary Univ., Alberta) et al. *In* ESA, Proceedings of the 8th ESA Symposium on European Rocket and Balloon Programs and Related Research p 401-404 Aug. 1987
Avail: NTIS HC A21/MF A01

It is proposed to fly high resolution auroral imaging instruments and particle spectrometers on the Columbus Polar Platform (PPF). A set of UV and X-ray imagers with wide field of view (horizon to horizon) will map the large scale (semiglobal) features of the aurora at day and night with fairly high spatial and temporal resolution. A set of visible and X-ray imagers and imaging spectrographs in visible and UV range with narrow field (NF) of view will give images with very high spatial resolution (better than 1 km and a few km respectively for optical and X-ray imagers) and a time resolution of 1 sec. The NF-imagers will be mounted on a pointable instrument pedestal to be operated in different modes. Particle spectrometers will cover electrons and ions over a wide energy range, and with high time resolution (10 ms). It is also desireable to fly a magnetometer. The particle and field instruments should be integrated in a separate package mounted on a boom protruding at least 10 m from the PPF, to minimize the contamination from the PPF environment.
ESA

N88-16298# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
TECHNICAL ASPECTS OF FUTURE OCEAN COLOUR REMOTE SENSING
M. RAST *In its* Ocean Colour Workshop p 27-28 Jul. 1987
Avail: NTIS HC A06/MF A01

Performance requirements for a Polar Platform Ocean color sensor are given. Spatial resolution = 0.5 x 0.5 km; swath width is at least 1500 km; spectral bandwidth = 10 nm (nominal) 5 nm (goal); radiometric resolution = 12 bit; q spectral bands minimum (visible/near infrared); global daily coverage; tilt mode to avoid sunlight; sensitivity sufficient for low reflecting targets (e.g., ocean surface at high latitude) in order to get data at low solar illumination conditions; and it is essential that the sensor is insensitive to polarization conditions of scattered light.
ESA

N88-16779# European Space Agency, Paris (France).
POLAR PLATFORM ELEMENT OF SPACE STATION: MISSION OBJECTIVES, EUROPEAN PRIORITIES, CANDIDATE INSTRUMENTATION AND SELECTION PROCEDURE
G. DUCHOSSOIS *In its* Proceedings of the ESA Workshop on Co-Orbiting Platform Elements (COPE) p 13-16 Sep. 1987
Avail: NTIS HC A04/MF A01

Use of Space Station platforms for observation of the atmosphere, oceans and ice, land processes, and solid Earth is discussed. It is stressed that the European program must be complementary to existing Earth observation programs developed within Europe and by other countries. Technological requirements

enable European industry to enhance competitivity in antennas, lasers, high speed electronics, optics, etc. Highest mission priorities are continuous monitoring of atmospheric, oceanic, and ice processes at global scale, and continuous monitoring of land processes and resources. Core instruments include active and passive microwave sensors, optical sensors, atmospheric sounder, and limb sounder. ESA

N88-16781# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Systems Engineering Dept.
TETHERS: AN OUTLINE OF A NEW CONCEPT FOR EARTH OBSERVATION
C. A. MARKLAND *In its* Proceedings of the ESA Workshop on Co-Orbiting Platform Elements (COPE) p 21-23 Sep. 1987
Avail: NTIS HC A04/MF A01

The tethered satellite concept is introduced, and the advantages of being able to fly sensors closer to the Earth's surface than is normally possible with spacecraft (e.g., 200 to 100 km altitude) are underlined. Tethers can also be used to fly several sensors with well defined separation. Problems arise in dynamics and control, and the tether can be damaged by heating or space debris. Columbus platforms could carry tethers. Earth observation missions, including high resolution remote sensing, gravity gradiometry, geomagnetic surveys, and atmospheric sounding are suggested. ESA

N88-16782# European Space Agency, Paris (France). Scientific Program Directorate.
USE OF SPACE STATION FOR SPACE SCIENCE
G. P. HASKELL *In its* Proceedings of the ESA Workshop on Co-Orbiting Platform Elements (COPE) p 25-26 Sep. 1987
Avail: NTIS HC A04/MF A01

Space Station cornerstone and other space science missions are outlined. The cornerstone missions are the comet nucleus sample return mission and the submillimeter heterodyne spectroscopy mission. Gamma ray spectroscopy, cosmic ray background anisotropy measurements, astroseismology, and stellar activity studies are suggested. The particulate content of near Earth space can be monitored and evaluated. Solar-terrestrial physics investigations are possible. The EURECA platform can be used for space science, in spite of its essentially microgravity payload orientation. ESA

N88-16783# European Space Agency, Paris (France). Microgravity Office.
MICROGRAVITY PAYLOADS AND MISSIONS FOR SPACE STATION: SOME ISSUES AFFECTING COMPATIBILITY WITH OTHER PAYLOADS
P. CLANCY *In its* Proceedings of the ESA Workshop on Co-Orbiting Platform Elements (COPE) p 27-28 Sep. 1987
Avail: NTIS HC A04/MF A01

Conflicts between Earth observation and space science and microgravity payloads on the Space Station are discussed. Earth observation and space science instruments, in order to be compatible with microgravity payloads, have to operate in such a way as to minimize disturbances transmitted to the carrier by pointing, scanning, and similar maneuvers. Microgravity payloads such as material science furnaces are likely (due to venting of volatile materials and gases) to produce considerable pollution of the external space environment near the spacecraft. This is likely to be a problem for optical instruments used for Earth observation or astronomy especially if cooled optical surfaces are involved where these materials could condense on and obscure the optics. Other conflicts involve competition for data channels, thermal compatibility, and competition for power. ESA

N88-16798# Sener S.A., Madrid (Spain).
COORBITING PLATFORM UTILIZATION STUDY (CPLUS), EXECUTIVE SUMMARY
A. ALDAMIZ Paris, France ESA 15 Jul. 1987 44 p
(SN-WP-4000-DOC-6609/85/F; ESA-CR(P)-2461; ETN-88-91416)
Avail: NTIS HC A03/MF A01

Accommodation for ESA payloads on the main truss structure of the space station was studied. It is concluded that the truss structure is suitable for the accommodation of attached payloads. European opportunity is very sensitive to American decisions and other user nation competition. Payload grouping on dedicated ESA carriers is the best way for an optimum usage of attachment points. The most promising attachment location on the truss structure is on the upper beam. The mission baseline schedule is too long due to European constraints. Items of flight and in-orbit resources demand the biggest funding effort (44 percent and 28 percent respectively). Man tended free flyers are suitable for small payloads. ESA

N88-16807# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
MULTISURFACE CONTROL MECHANISM FOR A DEPLOYABLE ANTENNA: FAR INFRARED AND SUBMILLIMETER SPACE TELESCOPE (FIRST) TECHNOLOGY STUDY Final Report
Paris, France ESA Jan. 1987 113 p Prepared in cooperation with Sener SA, Madrid (Spain)
(Contract ESTEC-5994/84-NL-AN(SC))
(RP-FA-D003; ESA-CR(P)-2506; ETN-88-91300) Avail: NTIS HC A06/MF A01

Antenna control for the Far Infrared and Submillimeter Space Telescope 8 m, foldable dish was investigated. The best fit contour of the reflector must not deviate from the ideal paraboloid by greater than 8 microns rms throughout the operational temperature range between minus 107 and minus 185 C. The structural design leads to CFRP sandwich shell elements on self supporting CFRP frameworks. Aluminum and Kevlar cores were studied as to their effects on thermally induced contour errors, and an error budget was established. Mechanisms for fixing the stowed and unfolded configuration and for panel deployment were defined. Methods for in-orbit calibration were identified and an on-ground adjustment concept for antenna assembly was defined. A panel with CFRP cover sheets and an Al core was exposed to a thermal cycling test, proving manufacturing accuracy and insensitivity to thermal loads. The suitability of the surface coating is demonstrated by microwave reflectivity measurements. Breadboard models of adjustment mechanisms for in-orbit correction of the main dish contour were successfully tested. ESA

N88-16810*# Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
KINETIC ISOLATION TETHER EXPERIMENT Annual Report
J. DAVID POWELL, XIAOHUA HE, and ROBERT SCHODER Feb. 1988 45 p
(Contract NCC2-389)
(NASA-CR-182458; NAS 1.26:182458) Avail: NTIS HC A03/MF A01 CSCL 22B

Progress was made on the analysis of tether damping and on experimentation of the control system on the laboratory simulator. The damping analysis considers the dynamics of a long tether connecting two spacecraft in Earth orbit, one of the spacecraft having dominant mass. In particular, it considers the material damping of the tether. The results show that, with properly chosen tether material and braiding structure, longitudinal vibration of the tethered system is well damped. A particularly effective method of implementing attitude control for tethered satellites is to use the tether tension force to generate control torques by moving the tether attach point relative to the satellite center of mass. A scaled, one dimensional laboratory simulation of the KITE mission was built and preliminary experiments of the proposed attitude control system were performed. The simulator was built to verify theoretical predictions of attitude controllability, and to investigate the technological requirements in order to implement this concept. A detailed description of the laboratory apparatus is provided, and in addition, the results of the preliminary experiments are presented and discussed. Author

N88-17891*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE 1987 GET AWAY SPECIAL EXPERIMENTER'S SYMPOSIUM
NEAL BARTHELME, ed. and FRANCES L. MOSIER, ed. (RMS Technologies, Inc., Landover, Md.) Feb. 1988 169 p Symposium held in Greenbelt, Md., 27-28 Oct. 1987
(NASA-CP-2500; REPT-88B0049; NAS 1.55:2500) Avail: NTIS HC A08/MF A01 CSCL 22A

The 1987 Get Away Special (GAS) Experimenter's symposium provides a formal opportunity for GAS Experimenter's to share the results of their projects. The focus of this symposium was on payloads that were flown on Shuttle missions, and on GAS payloads that will be flown in the future.

N88-19490# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
ASSEMBLY OF USER SYSTEMS AT SPACE STATION
HELMUT P. CLINE and THOMAS A. LAVIGNA *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 39-45 Nov. 1987
Avail: NTIS HC A21/MF A01

The technical and programmatic benefits of on-orbit assembly are outlined. Operational and automation considerations relating to on-orbit assembly are reviewed. Space Station capabilities for orbital assembly are discussed. ESA

N88-19526*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
EXPLORER PLATFORM ON-ORBIT SERVICING OPERATIONS
RUD V. MOE *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 373-376 Nov. 1987
Avail: NTIS HC A21/MF A01

Explorer Platform development and capabilities are outlined. The Explorer Platform extends the user provisions of the Multimission Modular Spacecraft to include power generation and distribution and on-orbit exchange of payload modules. The platform can be integrated with its payload and launched on an expendable launch vehicle or it can be carried separately from its payload on the Space Shuttle and assembled with its payload on-orbit. Later Shuttle flights can revisit the Platform to perform servicing or payload exchange. This capability to support several payloads in succession allows costs to be shared by several users over the 10 yr life of the platform. ESA

N88-19566*# Lunar and Planetary Inst., Houston, Tex.
PROGRESS TOWARD A COSMIC DUST COLLECTION FACILITY ON SPACE STATION
IAN D. R. MACKINNON, ed. and WILLIAM C. CAREY, ed. Jul. 1987 86 p Presented at the Workshop on Micrometeorite Capture Experiments, Houston, Tex., 28 Jun. - 1 Jul. 1987
(Contract NASW-4066)
(NASA-CR-182427; NAS 1.26:182427; LPI-TR-88-01) Avail: NTIS HC A05/MF A01 CSCL 22B

Scientific and programmatic progress toward the development of a cosmic dust collection facility (CDCF) for the proposed space station is documented. Topics addressed include: trajectory sensor concepts; trajectory accuracy and orbital evolution; CDCF pointing direction; development of capture devices; analytical techniques; programmatic progress; flight opportunities; and facility development. B.G.

16

OPERATIONS SUPPORT

Includes descriptions of models, analyses and trade studies of maneuvers, performance, Logistics support, and EVA and/or IVA servicing requirements of systems such as the OMV and OTV, and experiments.

A88-15288* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
SATELLITE SERVICING IN THE SPACE STATION ERA
THOMAS A. LAVIGNA and HELMUT P. CLINE (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 13 p.

The paper examines the lessons learned from past experiences, the requirements that apply to the various types of missions requiring servicing, and the present plans for establishing a system by which on-orbit servicing, assembly, and repair will become routine. It is noted that, by expanding on the servicing experience and capabilities provided directly by the STS, the Space Station will significantly enhance the mission objectives of long-duration scientific missions, not only by repair and consumable replenishment, but also by the addition and replacement of scientific instruments with upgraded versions. The servicing facility design is described, and a typical servicing scenario is presented. B.J.

A88-15290* Science Applications International Corp., Schaumberg, Ill.
TRANSITIONING FROM SPACE SHUTTLE TO SPACE STATION ON-ORBIT SERVICING
STEPHEN J. HOFFMAN (Science Applications International Corp., Schaumburg, IL) and GORDON RYSAVY (NASA, Johnson Space Center, Houston, TX) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 7 p.

On-orbit satellite servicing has been demonstrated on a variety of missions using the Space Shuttle. This capability is also a stated goal of the Space Station and other unmanned vehicles. Serviceable spacecraft should be able to take advantage of all these servicing facilities. This paper will discuss one effort to document currently available or nearly operational servicing interfaces. Availability of this type of compiled information will assist in a smooth transition from Shuttle-based satellite servicing to servicing at a wider range of locations and by different servicing vehicles. Author

A88-15291* TRW, Inc., Redondo Beach, Calif.
OMV SERVICING MISSIONS FROM SPACE STATION
JERRY L. JENNINGS (TRW, Inc., Redondo Beach, CA), JEROME L. WRIGHT (TRW, Inc., Huntsville, AL), and A. WAYNE DEATON (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 9 p.

The Orbital Maneuvering Vehicle (OMV) will provide a means of bringing large observatories to the Space Station for servicing and redeployment to their operating altitudes. However, there are many constraints which must be met in mission planning. The missions must be designed so that propellant consumption is within the usable allowance, but contingency operations can still be accomplished. The vehicle was designed specifically to accommodate such missions, with emphasis upon servicing the Hubble Space Telescope. The OMV has been designed for operations from the Shuttle Orbiter and the Space Station. It will readily accommodate basing at the Space Station and executing observatory retrieval and redeployment missions. Mission profiles have been designed which allow retrieval with contingency hold before descent, and which allow contingency return of the

observatory if it fails to reactivate properly. This capability will be a major addition to the Space Transportation System and will increase the utility of the Space Station. Author

A88-15292* Fairchild Space and Electronics Co., Germantown, Md.
ORBITAL SPACECRAFT CONSUMABLES RESUPPLY SYSTEM
THOMAS BERRY (Fairchild Space Co., Germantown, MD) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 16 p.
(Contract NAS9-17586)

This paper describes the work completed on the Orbital Spacecraft Consumables Resupply System (OSCRS) for the Johnson Space Center. The study objective was to provide a concept to NASA for supplying earth storable liquids and gases to a variety of orbiting vehicles, including Space Station, OMV and other satellites in orbits compatible with Shuttle resupply. The design is based on a cylindrical propellant tank optimized for transporting liquids in the Orbiter bay. The tank is polar mounted with the attachment fittings configured as Orbiter sill trunnions. The pressurant tanks provide support between the sill and keel fittings. Two potential spacecraft interface mechanisms were investigated. Continuing OSCRS effort will be directed toward further standardization studies, adapting the design to the Space Station Servicing Bay and investigating the possibilities of using ELV launchers. Author

A88-15521#
A PALLET-BASED SPACE PROGRAM FOR AUSTRALIA
J. SVED (Vega Space Systems Engineering, Ltd., Saint Albans, England) IN: National Space Engineering Symposium, 2nd, Sydney, Australia, Mar. 25-27, 1986, Preprints. Volume 2. Barton, Australia/Brookfield, VT, Institution of Engineers, Australia/Brookfield Publishing Co., 1986, 10 p. refs

Spacecraft carrier architectures relevant for the rapid development of an Australian space equipment and operations industry are discussed. An in-orbit-servicable or retrievable utility spacecraft based on the Spacelab Pallet structure is described. In order to establish a steady market share for such a multimission, multipayload system, an international consortium arrangement is proposed whereby Australian industry gains essential experience while the senior prime contractor is able to develop a market for what will become a standard utility spacecraft. Australian high-technology industry would thus gain early entry into the newly emerging space-business markets in LEO. Author

A88-15575
AN OVERVIEW OF SPACE STATION OPERATIONS
JAMES D. WALKER (Martin Marietta Corp. Denver, CO) and ROBERT L. ANDERSON (Lincom, Inc., Houston, TX) IN: An overview of space station operations; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 13-16, 1986. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE Proceedings SP-687), 1986, 47 p. refs
(SAE SP-687)

Results of analyses of Space Station operations and current key issues are discussed. In particular, attention is given to the Hubble Space Telescope and Orbital Maneuvering Vehicle retrieval and return to the Space Station for servicing; reboost scenarios for the Space Station and coorbiting free-flyers; candidate locations and techniques for the retrieval of unmanned vehicles on the Space Station structure; and logistics/resupply scenarios for the Space Station system. The discussion also covers artificial inteligence and expert systems applications for the Space Station. V.L.

A88-15808#
GEO PLATFORM SERVICING - TECHNOLOGY SOLUTIONS
TERRENCE G. REESE and CYRUS L. BUTNER (General Research Corp., Aerospace Systems Group, McLean, VA) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 14 p. refs
(IAF PAPER 87-08)

The servicing requirements for future GEO platforms are discussed, and technological issues associated with the servicing techniques and hardware are considered. The required technologies are identified through a study of two hypothetical future platforms: (1) a life science platform, representing a form of aggressive GEO utilization growth; and (2) a geostationary earth observation platform, representing a more modest form of GEO growth. A mix of manned and unmanned servicing is postulated to fulfill the requirements for consumable replenishment, experiment/instrument retrieval and replacement, and in-situ repair operations. R.R.

A88-15810*# National Aeronautics and Space Administration, Washington, D.C.
INTERNATIONAL SPACE STATION OPERATIONS: NEW DIMENSIONS - OCTOBER 13, 1987
GRANVILLE E. PAULES, PETER LYMAN, and CARL B. SHELLEY (NASA, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 17 p.
(IAF PAPER 87-13)

One of the principal goals of the participants in the International Space Station program is to provide a management support structure which is equitable and fair to all participants, responsive to the needs of users, responsible to other partners, and mutually supportive to the participation of other partners. Shared-utilization, shared-cost, and shared-operations policies considerations are discussed. Special attention is given to the methodology for identifying costs and benefits of this program, in which each partner should be provided with benefits in proportion to his contribution, and no partner would be forced to share in cost the inefficiencies introduced by other partners. The Space Station hierarchy of operations functions are identified, and the recommended framework planning and control hierarchy is presented. I.S.

A88-15825*# National Aeronautics and Space Administration, Washington, D.C.
AN OVERVIEW OF THE OFFICE OF SPACE FLIGHT SATELLITE SERVICING PROGRAM PLAN
GEORGE M. LEVIN and HARRY O. ERWIN, JR. (NASA, Office of Space Flight, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 8 p.
(IAF PAPER 87-35)

A comprehensive program for the development of satellite servicing tools and techniques is being currently carried out by the Office of Space Flight. The program is based on a satellite servicing infrastructure formulated by analyzing satellite servicing requirements; the program is Shuttle-based and compatible with the Orbital Maneuvering Vehicle and Space Station. The content of the satellite servicing program is reviewed with reference to the tools, techniques, and procedures being developed for refueling (or consumables resupply), repairing, and retrieving. V.L.

A88-15826*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
TECHNOLOGY ADVANCEMENTS FOR SERVICING OF FUTUPE SPACECRAFT SYSTEMS
F. J. CEPOLLINA (NASA, Goddard Space Flight Center, Greenbelt, MD) and P. M. BAY (Fairchild Space Co., Germantown, MD) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 10 p.
(IAF PAPER 87-36)

Problems associated with the in-orbit repair and maintenance of spacecraft systems are examined with reference to experience gained from three servicing missions: in-orbit capture, repair, and reflight of the Solar Maximum Mission satellite, capture and return to earth of the Palapa and Westar communications satellites, and in-orbit repair of Syncom 3. It is then shown how the lessons learned from the three servicing missions are applied to current and future servicing activities. In particular, planned servicing missions for the Hubble Space Telescope, tools and servicing

facilities development, and the development of the Explorer Platform are discussed. V.L.

A88-15829#
LOGISTICS FLOW FOR COLUMBUS MTFF
PATRICK EYMAR (Aerospatiale, Les Mureaux, France) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 8 p. refs
(IAF PAPER 87-39)

The logistics aspects of the Columbus Man Tended Free Flyer (MTFF) are reviewed with reference to results of several different studies. It is shown that the architecture of the in-orbit elements and the selection, design, and use of transportation to carry the logistics cargo have an important impact on the logistics of the MTFF. Of great importance are also cost factors. Another important consideration is the share of logistics cargo the recovery of which is of no or small interest. Depending on this percentage, a better optimization of the HERMES and LOVE designs and ways of their utilization will be possible. V.L.

A88-15831#
ON-ORBIT SERVICING AND COST EFFECTIVENESS OF COLUMBUS POLAR PLATFORM CONCEPTS
D. C. FERNS (Logica Space and Defence Systems, Ltd., Cobham, England), C. LEE (British Aerospace, PLC, Filton, England), and R. HATHAWAY (Marconi Space Systems, Ltd., Portsmouth, England) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 5 p. refs
(IAF PAPER 87-42)

The determination of the servicing requirements for the Polar Platform element of ESA's Columbus space station component, with respect both to the platform and its payloads, is highly dependent on the engineering reliability index that is used as the planned interval to replacement, as well as on management decisions at the level of operational system reliability. It is found that on-orbit servicing of a large polar platform is cost-effective relative to a series of smaller expendable spacecraft supporting the same operational payloads, even when the small spacecraft are given an optimistic service life of 5 years. O.C.

A88-15856*# National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION PROGRAM IMPLICATIONS FROM THE VIEWPOINT OF THE SPACE STATION OPERATIONS TASK FORCE
GRANVILLE E. PAULES, PETER LYMAN, and CARL B. SHELLEY (NASA, Space Station Operations Task Force, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 8 p.
(IAF PAPER 87-82)

An operational concept for the Space Station which has been developed by the Space Station Operations Task Force is described. The operations functions are described, and the relationships of these functions to the overall framework for operations are defined. Product flows for the recommended framework are discussed, and the roles and responsibilities for the proposed operations organization during both the development and the mature operations phases of the Space Station Program are examined. C.D.

A88-15859*# National Research Council of Canada, Ottawa (Ontario).
ASSEMBLING, MAINTAINING AND SERVICING SPACE STATION
K. H. DOETSCH, H. WERSTIUK (National Research Council of Canada, Space Div., Ottawa), W. CREASY (NASA, Johnson Space Center, Houston, TX), and R. BROWNING (NASA, Goddard Space Flight Center, Greenbelt, MD) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 10 p.
(IAF PAPER 87-85)

The assembly, maintenance, and servicing of the Space Station and its facilities are discussed. The tools and facilities required for the assembly, maintenance, and servicing of the Station are described; the ground and transportation infrastructures needed for the Space Station are examined. The roles of automation and robotics in reducing the EVAs of the crew, minimizing disturbances to the Space Station environment, and enhancing user friendliness are investigated. Servicing/maintenance tasks are categorized based on: (1) urgency, (2) location of servicing/maintenance, (3) environmental control, (4) dexterity, (5) transportation, (6) crew interactions, (7) equipment interactions, and (8) Space Station servicing architecture. An example of a servicing mission by the Space Station for the Hubble Space Telescope is presented. I.F.

A88-15948*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
DEVELOPMENT OF A COOPERATIVE OPERATIONAL RENDEZVOUS PLAN FOR EURECA AND OTHER MANEUVERING SHUTTLE PAYLOADS
R. T. GAVIN (NASA, Johnson Space Center, Houston, TX) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 9 p. refs
(IAF PAPER 87-218)

This paper discusses the development of a new class of US Space Shuttle rendezvous missions which involve a maneuvering target vehicle. The objective of the analysis was to develop an operational plan to take advantage of the target spacecraft's maneuvering ability by making it responsible for a portion of the maneuvers necessary to achieve rendezvous. This work resulted in the development of a region in space relative to the Shuttle, called the control box, into which the target vehicle maneuvers. Furthermore, a mission operations plan was developed to implement the control box technique. Author

A88-15949#
SPACE STATION SUPPLY, PRODUCT RETURN, AND TRASH DISPOSAL
R. V. GLOWCZWSKI (Martin Marietta Corp., New Orleans, LA) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 14 p.
(IAF PAPER 87-219)

A technique is presented which relates the Space Station's average supply and products requirements, boost capability, and flight number per year to carrier sizes and the required inert mass fraction. Approaches are discussed which can alleviate the National Space Transportation System launch versus landing capability imbalance caused by the introduction of expendable launch vehicles into the Space Station logistics system. A pressurized logistics design has been developed that has manifest flexibility, a sufficiently low inert mass fraction, and cargo load flexibility to allow resupply requirements to be satisfied. K.K.

A88-20475
ASSEMBLING THE SPACE STATION
PHILIP CHIEN Space World (ISSN 0038-6332), vol. X-12-288, Dec. 1987, p. 16-20.

The sequence of events by which the NASA Space Station will be assembled is reviewed. The purposes of the various planned Manned Base flights and Logistics flights are summarized. The structural, functional, and operational differences between the Space Station and Skylab are described. C.D.

A88-21095
EVA FOR A EUROPEAN SCENARIO
NIKOLAUS HERBER (Dornier System GmbH, Friedrichshafen, Federal Republic of Germany) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 9 p.
(SAE PAPER 871432)

A new project has been established in the European Space Scenario namely the build up of a European EVA capability, based on both the request for European autonomy and the realization that EVA is a part of manned spaceflight. As a major element of EVA Systems, a medium pressure hybrid suit is proposed allowing a prebreathing-free transition from the Hermes cabin (700 hPa) into the suit. Development risk factors seems to be medium -

with the exception of some critical items - so that a basic European EVA capability might be available for the first Hermes flight on 1998. Author

A89-21148
ON-ORBIT SERVICING ENHANCEMENTS WITH CREWLOCK EVA OPERATIONS FROM THE SPACEHAB MODULE
WILLIAM E. HAYNES (Science Applications International Corp., La Jolla, CA), THOMAS C. TAYLOR, and ROBERT CITRON (SPACEHAB, Inc., Seattle, WA) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 12 p.
(SAE PAPER 871496)

The design and the operation principles of the Crewlock device (to be used in conjunction with the Spacehab module) for EVA operations are discussed. In Crewlock, the task of transiting from a volume at one pressure to another volume at a different pressure is approached in a manner different from that of airlocks. A Crewlock transit chamber is close form-fit to the transiting body; thus, the loss of and possible contaminants from pressurant gases become negligible; the need for pumps is eliminated; the mass, volume, and complexity of the lock is reduced; and the time required for transit is shorter. The Spacehab module will accomodate the Crewlock and provide storage space for the added suit components and expendables. By using Crewlock in a Spacehab module, the permissible working EVA's on a single Shuttle flight will be limited only by the Shuttle stay time and the crew endurance; if alternate crewmembers are available, the Space Station assembly manhours can be increased to over 100 hrs for a ten day orbit stay. I.S.

A89-21149
DEVELOPMENT OF AN AUTOMATED CHECKOUT, SERVICE, AND MAINTENANCE SYSTEM FOR AN EVAS SPACE STATION
FRED J. ABELES and ANTHONY C. BEARDSLEY (Grumman Corp., Space Systems Div., Bethpage, NY) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 10 p.
(SAE PAPER 871497)

The EVA System envisioned for the NASA Space Station requires a checkout, service and maintenance (COSM) system, whose architecture is presently defined. COSM will be responsible for EVA sequencing, operational checkouts, calibration, fault detection/isolation, and postperformance checkout. The COSM computer system architecture is designed to satisfy the unique demands of the preprototype requirements, including the provision of a communication port for the Space Station data management system. O.C.

A89-21150* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
NEW TOOLS FOR EVA OPERATIONS
C. E. WHITSETT (NASA, Johnson Space Center, Houston, TX) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 12 p.
(SAE PAPER 871499)

Effective extravehicular-activity (EVA) operations depend upon having the proper tools from simple wrenches to smart powered socket drives to powered adjustable foot restraints. The Space Shuttle carries a standard toolkit in the cargo bay for emergencies. Many special tools have been developed for the recent satellite repair missions; i.e., Solar Max, Westar/Palapa, and Leasat. Many more are being developed to maintain the Hubble Space Telescope on orbit for 15 years. The EVA tools developed and used in space to date are summarized and some of the new tools now in development are described herein. Finally, the requirements are given for several additional tools which may be needed in the future. Author

A89-21637
AUTOMATIC PLANNING RESEARCH APPLIED TO ORBITAL CONSTRUCTION
WILLIAM T. PARK (SRI International Applied Artificial Intelligence Laboratory, Menlo Park, CA) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 59-66. refs
(Contract N00014-83-C-0649; N00014-85-C-0294; NSF ECS-82-00615)

Parplan, a recently developed experimental automatic planning program for the Space Station, is described. The implementation, internal representations and operation, goals and actions, plan refinement, constraints on the order of events, action descriptions, subgoals, planning process, and design objectives pertaining to Parplan are addressed. A review is also given of issues in automatic planning for Space Station construction. C.D.

A89-21653* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE SOLAR MAXIMUM MISSION REPAIR - LESSONS LEARNED
BRUCE E. WOODGATE and STEPHEN P. MARAN (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 202-209.

The on-orbit repair sequence of the Solar Maximum Mission in April 1984 is described, and important lessons learned concerning orbital debris are summarized. Scientific results pertaining to a solar flare which occurred just before the repair are reviewed. The implications of the repair experience for serviceability in the design of future spacecraft and instruments are illustrated by the case of the Hubble Space Telescope and its second generation spectrograph. C.D.

A88-22277*# General Sciences Corp., Laurel, Md.
EFFICIENT SPACECRAFT FORMATIONKEEPING WITH CONSIDERATION OF BALLISTIC COEFFICIENT CONTROL
MICHAEL MATHEWS (General Sciences Corp., Landover, MD) and SUZAN J. LESZKIEWICZ (NASA, Goddard Space Flight Center, Greenbelt, MD) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(AIAA PAPER 88-0375)

The extent to which drag can be used to enhance retrieval and servicing of platforms in the Space Staion environment is investigated for the case when separations on the order of several hundred or even thousands of kilometers occur over extended, but predefined, periods of time. The nature of the problem is formulated, the analytical tools used are described, and the mathematical foundation of the analysis is presented. Results are reported for the cases of formation flying cycles without ballistic coefficient control, formation flying with controlled relative decay, and the effects of varying solar activity. C.D.

A88-22334*# Computer Technology Associates, Inc., Lanham, Md.
THE GSFC FLIGHT SUPPORT SYSTEM FOR ON-ORBIT SATELLITE SERVICING
THOMAS J. GRIFFIN (Computer Technology Associates, Inc., Lanham, MD) and WILLIAM N. STEWART (NASA, Goddard Space Flight Center, Greenbelt, MD) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. refs
(AIAA PAPER 88-0448)

To plan and execute a successful on-orbit satellite servicing mission, space support hardware, a serviceable spacecraft design, and flexible ground operations are required. This paper addresses space support hardware and in particular the Goddard Space Flight Center (GSFC) Satellite Servicing Project's (SSP) Flight Support System (FSS). The FSS is designed to be compatible with the Space Transportation System Orbiter and to support on-orbit servicing of Multimission Modular Spacecraft. It provides mechanical, electrical, and thermal support to the spacecraft during the servicing mission. Standardization of spacecraft design, components, and interfaces is required to make a satellite serviceable. Spacecraft ground operation capabilities must accommodate servicing mission requirements. Space support tools

and equipment, such as the Power Ratchet Tool, assists the astronaut during time critical EVA operations to more efficiently perform the servicing mission. Author

A88-23990#
MAN TENDED FREE FLYER CONFIGURATIONS AND SERVICING SCENARIOS
H. FRIEDRICH (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany), A. J. THIRKETTLE (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands), and H. G. FRANCOIS (Dornier System GmbH, Friedrichshafen, Federal Republic of Germany) Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987, Paper. 20 p.
(MBB-UR-E-984-87)

This paper describes the main design features incorporated in the ESA's Man-Tended Free Flyer (MTFF) which enable it to be operational on-orbit for a 30-year period via servicing and maintenance. The mission scenario is reviewed, and the MTFF design for on-orbit servicing is described. The servicing of the MTFF by the ISS and Hermes is considered. C.D.

A88-27778#
REPPRE-REPSIM-REPSTA - PROGRAMS FOR EVALUATING THE AVAILABILITY AND MAINTENANCE OF SPACE SYSTEMS
J. C. DEBRUYN and C. S. JENKS (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) ESA Journal (ISSN 0379-2285), vol. 11, no. 3, 1987, p. 297-315.

A computer simulation suite called REPSIM has been developed at ESTEC to enable the solution of a class of problems relating to the availability and maintenance of communications and other application satellite systems. Current conventional systems can be modeled, as can the most advanced systems envisaged, such as clusters and repairable assemblies. The result is a tool that has applications in planning, design and risk analysis. Author

A88-31379#
SHUTTLE BASED ASSEMBLY OF SPACE STATION
KAREN R. ARCHARD (Rockwell International Corp., Space Transportation Systems Div., Downey, CA) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 14-22.
(AIAA PAPER 88-2452)

Relying primarily on underwater neutral buoyancy simulations at Johnson Space Center's Weightless Environment Training Facility, Shuttle-based assembly tasks involving the assembly fixture, truss structure joint design, and utility tray concepts were evaluated. The results indicate that construction of the Integrated Truss Assembly by EVA is practical via any of the methods examined. Truss joint configuration and the installation sequence were found to be critical to assembly. A positive lock-lock feature for joints and a marking scheme to aid in installation was developed. Utility installation findings favored deployable trays with quick attach mechanisms. C.D.

A88-31381#
EVA CONSTRUCTION AND REPAIR OF TUBULAR SYSTEMS ON SPACE STATION
RAY H. ANDERSON and SHIRLEY J. PEARSON (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 32-38. refs
(AIAA PAPER 88-2456)

The components of a study program on the EVA construction and repair of tubular systems on the Space Station are described. The program involves: (1) determining the feasibility of using metallurgical processes for tube joining; (2) determining the feasibility of installing and repairing currently available aerospace tube fittings in environments typical of those for the Space Shuttle; (3) evaluating the ability of EVA-suited subjects to assemble or disassemble candidate quick-disconnect couplings; and (4) leak testing of both installed and repaired tube fittings and assembled quick-disconnect couplings at pressures and thermal cycles expected for the Space Station. C.D.

A88-31382*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ASTRONAUT/EVA CONSTRUCTION OF SPACE STATION
WALTER L. HEARD, JR., HAROLD G. BUSH, JUDITH J. WATSON (NASA, Langley Research Center, Hampton, VA), SHERWOOD C. SPRING, and JERRY L. ROSS (NASA, Johnson Space Center, Houston, TX) IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 39-46. refs
(AIAA PAPER 88-2459)

Four early space construction tests performed in neutral buoyancy and/or on-orbit to evaluate EVA for assembly of truss structures are reviewed and astronaut observations are presented. In addition, two ongoing ground test programs that address EVA assembly of full scale Space Station truss structure using a mobile transporter equipped with astronaut positioning arms are described. A truss joint design that enables EVA assembly while meeting structural design goals is also discussed. Author

A88-32476* National Aeronautics and Space Administration, Washington, D.C.
REUSABLE SPACE SYSTEMS (EUGEN SAENGER LECTURE, 1987)
J. C. FLETCHER (NASA, Washington, DC) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 12, Jan.-Feb. 1988, p. 1-5.

The history and current status of reusable launch vehicle (RLV) development are surveyed, with emphases on the contributions of Eugen Saenger and ongoing NASA projects. Topics addressed include the capabilities and achievements of the Space Shuttle, the need to maintain a fleet with both ELVs and RLVs to meet different mission requirements, the X-30 testbed aircraft for the National Aerospace Plane program, current design concepts for Shuttle II (a 1000-ton fully reusable two-stage rocket-powered spacecraft capable of carrying 11,000 kg to Space Station orbit), proposals for dual-fuel-propulsion SSTO RLVs, and the Space Station Orbital Maneuvering Vehicle and Orbital Transfer Vehicle. The importance of RLVs and of international cooperation in establishing the LEO infrastructure needed for planetary exploration missions is stressed. T.K.

N88-10089*# Air Force Space Div., Los Angeles, Calif.
SPACE ASSEMBLY, MAINTENANCE, AND SERVICING STUDY (SAMSS)
JOSEPH WONG *In* NASA-Lewis Research Center, Spacecraft 2000 p 59-69 Jul. 1986
Avail: NTIS HC A11/MF A01 CSCL 22B

The goal is to define and establish Space Assembly, Maintenance, and Servicing (SAMS) capabilities to meet requirements for improved space systems. Consolidated requirements, hardware/tool concepts, systems analysis, related studies interaction, and schedule/milestones are outlined. This presentation is represented by charts and figures only. B.G.

N88-10100*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACE STATION ASSEMBLY/SERVICING CAPABILITIES
JOSEPH JOYCE *In its* Spacecraft 2000 p 77-84 Jul. 1986
Avail: NTIS HC A11/MF A01 CSCL 22B

The aim is to place a permanently manned space station on-orbit around the Earth, which is international in scope. The program is nearing the close of the system definition and preliminary design phase. The first shuttle launch for space station assembly on-orbit is estimated for January 1993. Topics perceived to be important to on-orbit assembly and servicing are discussed. This presentation is represented by charts. B.G.

N88-10871*# National Aeronautics and Space Administration, Washington, D.C.
THE FLIGHT DEMONSTRATION PROGRAM AND SELECTION PROCESS
G. M. LEVIN *In* NASA. Langley Research Center, Hampton, Va. Space Construction p 5-12 Oct. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

The Orbital Refueling System (ORS); force torque sensor; Plasma Motor/Generator (PMG) proof of function; voice controlled system; infrared intercommunications; superfluid helium on orbit transfer; laser docking sensor; and the Small Expendable Deployment System (SEDS) are summarized. B.G.

N88-10879*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
A SYNOPSIS OF THE EVA TRAINING CONDUCTED ON EASE/ACCESS FOR STS-61-B
KATHRYN A. HAVENS *In* NASA. Langley Research Center, Hampton, Va. Space Construction p 153-182 Oct. 1987
Avail: NTIS HC A14/MF A01 CSCL 05I

Experimental Assembly of Structure in EVA (EASE)/Assembly Concept for Construction of Erectable Space Structures (ACCESS) training problems; photography/television coverage; training schedules; flight data file (FDF), and flight rules production are summarized. B.G.

N88-10881*# Massachusetts Inst. of Tech., Cambridge. Space Systems Lab.
EASE (EXPERIMENTAL ASSEMBLY OF STRUCTURES IN EVA) OVERVIEW OF SELECTED RESULTS
DAVID L. AKIN *In* NASA. Langley Research Center, Hampton, Va. Space Construction p 199-227 Oct. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

Experimental Assembly of Structures in EVA (EASE) objectives, experimental protocol, neutral buoyancy simulation, task time distribution, assembly task performance, metabolic rate/biomedical readouts are summarized. This presentation is shown in charts, figures, and graphs. B.G.

N88-11686*# Rockwell International Corp., Downey, Calif. Space Transportation Systems Div.
ORBITAL SPACECRAFT CONSUMABLES RESUPPLY SYSTEM (OSCRS). VOLUME 4: EXTENDED STUDY RESULTS Final Report
Sep. 1987 120 p
(Contract NAS9-17584)
(NASA-CR-172012; NAS 1.26:172012; STS-86-0302-4-VOL-4; DRD-10-VOL-4; CDRL-MA-1023T-VOL-4) Avail: NTIS HC A06/MF A01 CSCL 22A

The objectives consisted of three major tasks. The first was to establish the definition of Space Station and Orbital Maneuvering Vehicle (OMV) user requirements and interfaces and to evaluate system requirements of a water tanker to be used at the station. The second task is to conduct trade studies of system requirements, hardware/software, and operations to evaluate the effect of automatic operation at the station or remote from the station in consonance with the OMV. The last task is to evaluate automatic refueling concepts and to evaluate the impact to Orbital Spacecraft Consumable Resupply System (OSCRS) concept/design to use expendable launch vehicles (ELV) to place the tank into orbit. Progress in each area is discussed. B.G.

N88-11687*# Rockwell International Corp., Downey, Calif. Space Transportation Systems Div.
ORBITAL SPACECRAFT CONSUMABLES RESUPPLY SYSTEM (OSCRS). VOLUME 2: STUDY RESULTS Final Report
Mar. 1987 156 p
(Contract NAS9-17584)
(NASA-CR-172011; NAS 1.26:172011; STS-86-0302-2A-VOL-2; DRD-10-VOL-2; CDRL-MA-1023T-VOL-2) Avail: NTIS HC A08/MF A01 CSCL 22A

The objective was to establish an earth storable fluids tanker concept which satisfies the initial resupply requirements for the Gamma Ray Observatory (GRO) for reasonable front end (design, development, verification) cost while providing growth potential for foreseeable future earth storable resupply mission requirements. The achievement of these objectives becomes possible with the development of a modularized tanker concept which is a hybrid of a dedicated GRO tanker and a generic earth storable propellant tanker. Author

N88-11741*# Martin Marietta Corp., Denver, Colo. Astronautics Group.
ORBITAL SPACECRAFT CONSUMABLES RESUPPLY SYSTEM (OSCRS): MONOPROPELLANT APPLICATION TO SPACE STATION AND OMV AUTOMATIC REFUELING IMPACTS OF AN ELV LAUNCH, VOLUME 4 Final Report
Sep. 1987 133 p
(Contract NAS9-17585)
(NASA-CR-172029; NAS 1.26:172029; MCR-87-1339-VOL-4; DRD-10-VOL-4) Avail: NTIS HC A07/MF A01 CSCL 22B

The use of orbital spacecraft consumables resupply system (OSCRS) at the Space Station is investigated, its use with the orbital maneuvering vehicle, and launch of the OSCRS on an expendable launch vehicles. A system requirements evaluation was performed initially to identify any unique requirements that would impact the design of OSCRS when used at the Space Station. Space Station documents were reviewed to establish requirements and to identify interfaces between the OSCRS, Shuttle, and Space Station, especially the Servicing Facility. The interfaces between OSCRS and the Shuttle consists of an avionics interface for command and control and a structural interface for launch support and for grappling with the Shuttle Remote Manipulator System. For use of the OSCRS at the Space Station, three configurations were evaluated using the results of the interface definition to increase the efficiency of OSCRS and to decrease the launch weight by Station-basing specific OSCRS subsystems. A modular OSCRS was developed in which the major subsystems were Station-based where possible. The configuration of an OSCRS was defined for transport of water to the Space Station. Author

N88-13368*# Rockwell International Corp., Downey, Calif. Space Transportation Systems Div.
ORBITAL SPACECRAFT CONSUMABLES RESUPPLY SYSTEM (OSCRS). VOLUME 1: EXECUTIVE SUMMARY Final Report
Mar. 1987 73 p
(Contract NAS9-17584)
(NASA-CR-172010; NAS 1.26:172010; STS-86-0302-1A-VOL-1; DRD-10-VOL-1; CDRL-MA-1023T-VOL-1) Avail: NTIS HC A04/MF A01 CSCL 22A

The objective was to establish an earth storable fluid tanker concept which satisfies the initial resupply requirements for the Gamma Ray Observatory (GRO) at a reasonable front end cost while providing growth potential for foreseeable future earth storable fluid resupply mission requirements. The estimated costs required to design, develop, qualify, fabricate, and deliver a flight tanker and its associated control avionics, ground support equipment (GSE), and processing facilities, and the contractors costs to support the first operations mission are reviewed. B.G.

N88-13369*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DESIGN AND ASSEMBLY SEQUENCE ANALYSIS OF OPTION 3 FOR CETF REFERENCE SPACE STATION
L. BERNARD GARRETT, GREGORY C. ANDERSEN, JOHN B. HALL, JR., CHERYL L. ALLEN, A. D. SCOTT, JR., and KENNETH T. SO (Rockwell International Corp., Downey, Calif.) Nov. 1987 83 p
(NASA-TM-100503; NAS 1.15:100503) Avail: NTIS HC A05/MF A01 CSCL 22B

A design and assembly sequence was conducted on one option of the Dual Keel Space Station examined by a NASA Critical Evaluation Task Force to establish viability of several variations of that option. A goal of the study was to produce and analyze technical data to support Task Force decisions to either examine particular Option 3 variations in more depth or eliminate them

from further consideration. An analysis of the phasing assembly showed that use of an Expendable Launch Vehicle in conjunction with the Space Transportation System (STS) can accelerate the buildup of the Station and ease the STS launch rate constraints. The study also showed that use of an Orbital Maneuvering Vehicle on the first flight can significantly benefit Station assembly and, by performing Station subsystem functions, can alleviate the need for operational control and reboost systems during the early flights. In addition to launch and assembly sequencing, the study assessed stability and control, and analyzed node-packaging options and the effects of keel removal on the structural dynamics of the Station. Results of these analyses are presented and discussed. Author

N88-14118*# Martin Marietta Aerospace, Denver, Colo.
CONCEPT DEFINITION STUDY FOR RECOVERY OF TUMBLING SATELLITES. VOLUME 1: EXECUTIVE SUMMARY, STUDY RESULTS Final Technical Report
D. A. CABLE, W. L. DEROCHER, JR., J. A. CATHCART, M. G. KEELEY, L. MADAYEV, T. K. NGUYEN, and J. R. PREESE Jun. 1986 212 p
(Contract NAS8-36609)
(NASA-CR-179228; NAS 1.26:179228; MCR-86-1329-VOL-1; DPD-654; DR-6) Avail: NTIS HC A10/MF A01 CSCL 22B

The first assessment is made of the design requirements and conceptual definition of a front end kit to be transported on the currently defined Orbital Maneuvering Vehicle (OMV) and the Space Transportation System Shuttle Orbiter, to conduct remote, teleoperated recovery of disabled and noncontrollable, tumbling satellites. Previous studies did not quantify the dynamic characteristics of a tumbling satellite, nor did they appear to address the full spectrum of Tumbling Satellite Recovery systems requirements. Both of these aspects are investigated with useful results. Author

N88-14120# Societe Nationale Industrielle Aerospatiale, Les Mureaux (France). Div. Systemes Strategiques et Spatiaux.
RENDEZVOUS AND DOCKING VERIFICATION (RVDV) AND IN-ORBIT DEMONSTRATION, EXECUTIVE SUMMARY Final Report
H. P. NGUYEN Paris, France ESA 11 Feb. 1987 89 p
(Contract ESA-6493/85-NL)
(RVD-RVDV-FR-AS-01; SE/LS/AP-33-994; ESA-CR(P)-2452; ETN-88-91149) Avail: NTIS HC A05/MF A01

Space rendezvous and docking (RVD) items to be verified, and verification methods from ground analysis/simulation to in-orbit testing, are listed. Space missions for 1988 to 1993 were reviewed for opportunities to implement elements of the verification plan. A global RVD demonstration mission in low Earth orbit is designed to complete the verification cycle. Platforms EURECA A and EURECA B are designated as target and chaser vehicles, one being retrieved, the other deployed during one flight of the space shuttle. Nearly no in-orbit experiment is necessary before final system demonstration for verification proper. However technology demonstrations in-orbit are of high interest to increase confidence of users and political partners. ESA

N88-15095*# Martin Marietta Aerospace, Denver, Colo. Space Systems.
SERVICER SYSTEM DEMONSTRATION PLAN AND CAPABILITY DEVELOPMENT Final Technical Report
Dec. 1987 250 p
(Contract NAS8-35625)
(NASA-CR-179246; NAS 1.26:179246; MCR-87-1352; DPD-650-DR-5) Avail: NTIS HC A11/MF A01 CSCL 13B

An orbital maneuvering vehicle (OMV) front end kit is defined which is capable of performing in-situ fluid resupply and modular maintenance of free flying spacecraft based on the integrated orbital servicing system (IOSS) concept. The compatibility of the IOSS to perform gas and fluid umbilical connect and disconnect functions utilizing connect systems currently available or in development is addressed. A series of tasks involving on-orbit servicing and the engineering test unit (ETU) of the on-orbit service were studied. The objective is the advancement of orbital servicing by expanding the Spacecraft Servicing Demonstration Plan (SSDP) to include detail demonstration planning using the Multimission Modular Spacecraft (MMS) and upgrading the ETU control. B.G.

N88-15930*# TRW, Inc., Redondo Beach, Calif.
SAMSS: AN IN-PROGRESS REVIEW OF THE SPACECRAFT ASSEMBLY, MAINTENANCE, AND SERVICING STUDY
WILLIAM W. BURT *In* NASA. Lewis Research Center, Cleveland, Ohio. Cryogenic Fluid Management Technology Workshop. Volume 1: Presentation Material and Discussion p 117-137 Sep. 1987
(Contract F04701-86-C-0032)
Avail: NTIS HC A17/MF A01 CSCL 20D

The Spacecraft Assembly, Maintenance, and Servicing Study (SAMSS) is an effort to define and verify the most cost effective approach to spacecraft servicing, as a alternative to replacement in the 1990's and beyond. The intent of the study is to assess the servicing of satellites in all orbit regimes. Elements of a space servicing infrastructure are developed and cost estimates are generated. Readiness is assessed and proof of concept demonstrations are identified. Cryogenic fuel resupply is discussed. Author

N88-16769# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Communications Satellite Dept.
SATELLITE ASSEMBLY IN GEOSTATIONARY ORBIT: A PLUG-AND-SOCKET CONCEPT
A. W. PREUKSCHAT *In its* ESA Bulletin No. 25 p 10-15 Feb. 1981
Avail: NTIS HC A05/MF A01

A space-segment construction concept, satellite assembly in geostationary orbit, is described. It can remove mass constraints and appears to have the potential to reduce procurement costs for future communications space segments. A possible configuration has a power-augmented service module (EM) satellite system (the socket) and four payload module (PM) satellites attached (the plugs). The assembly sequence could be launch of the basic SM satellite; launch and docking of three (small) PM satellites, launch and docking of the PFM satellite to augment the system's power capabilities prior to launch and docking of a large, high-power Payload-Module satellite; subsequent launch and attachment of a fourth (small) PM satellite. Author (ESA)

N88-18619*# Smith Advanced Technology, Inc., Huntsville, Ala.
SPACE STATION OPERATING SYSTEM STUDY Summary Report
ALBERT E. HORN and MORRIS C. HARWELL Feb. 1988 175 p
(Contract NAS8-36462)
(NASA-CR-179308; NAS 1.26:179308; SAT88-0002) Avail: NTIS HC A08/MF A01 CSCL 22B

The current phase of the Space Station Operating System study is based on the analysis, evaluation, and comparison of the operating systems implemented on the computer systems and workstations in the software development laboratory. Primary emphasis has been placed on the DEC MicroVMS operating system as implemented on the MicroVax II computer, with comparative analysis of the SUN UNIX system on the SUN 3/260 workstation computer, and to a limited extent, the IBM PC/AT microcomputer running PC-DOS. Some benchmark development and testing was also done for the Motorola MC68010 (VM03 system) before the system was taken from the laboratory. These systems were studied with the objective of determining their capability to support Space Station software development requirements, specifically for multi-tasking and real-time applications. The methodology utilized consisted of development, execution, and analysis of benchmark programs and test software, and the experimentation and analysis of specific features of the system or compilers in the study. Author

N88-19484# European Space Agency, Paris (France).
PROCEEDINGS OF THE 1ST EUROPEAN IN-ORBIT OPERATIONS TECHNOLOGY SYMPOSIUM
E. J. ROLFE, ed. Nov. 1987 497 p Symposium held in Darmstadt, Fed. Republic of Germany, 7-9 Sep. 1987; sponsored by ESA and DGLR
(ESA-SP-272; ISSN-0379-6566; ETN-88-91971) Avail: NTIS HC A21/MF A01

In-orbit scenarios; orbital rendezvous and docking; orbital assembly and servicing; spacecraft design; robotics; artificial intelligence and expert systems; ground simulation and modeling; teleoperation; and technology demonstration were discussed. ESA

N88-19485# Erno Raumfahrttechnik G.m.b.H., Bremen (West Germany).
MAN-TENDED FREE FLYER OPERATIONAL DESIGN FEATURES
H. FRIEDRICH and A. J. THIRKETTLE (European Space Agency, European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p xxii-xxviii Nov. 1987
Avail: NTIS HC A21/MF A01

Design features which enable ESA's Man-Tended Free Flyer (MTFF) to be operational on-orbit for a 30 yr period via servicing and maintenance are described. The MTFF is to be serviced at the Station or by Hermes every 6 months using man in the Pressurized Module (PM) and using robotics for the external equipment. Extravehicular activity is a contingency back-up to the latter. Crew servicing inside the PM is enhanced by design details allowing good access to the payload and subsystem equipment in the same manner as for the Attached Modules of the Station, that is by mounting all equipment in standard racks to which the crew have easy access. Servicing of the external items is achieved by mounting them in Orbital Replacement Units (ORU's) which are compatible with the Station and/or Hermes manipulator arms. The ORU's have standardized interface provisions for end effectors and also for attachment to their parent spacecraft. There are also nonstandard ORU's such as solar arrays and antennas. The MTFF has attitude/orbit control, stability, and position features, has RVD sensors and propulsive capabilities for orbit maintenance, transfer, and rendezvous functions. ESA

N88-19498*# National Aeronautics and Space Administration, Washington, D.C.
NASA OFFICE OF SPACE FLIGHT (OSF) IN-ORBIT SERVICING PROGRAM
GEORGE C. LEVIN and HARRY O. ERWIN, JR. *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 113-122 Nov. 1987
Avail: NTIS HC A21/MF A01 CSCL 22A

Tools, fixtures and systems being developed to improve the efficiency of extravehicular activity (EVA) servicing operations; and tools developed for EVA use being adapted for use in robot-assisted EVA, local robotic servicing, and remote robotic servicing, are presented. The basic types of satellite servicing operations, the various modes by which they can be accomplished, and the hardware which supports these modes are outlined. The program and hardware elements of the program infrastructure are reviewed. ESA

N88-19503*# National Aeronautics and Space Administration, Lyndon B. Johnson Space Center, Houston, Tex.
CUSTOMER CONCERNS REGARDING SATELLITE SERVICING
GORDON RYSAVY *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 159-161 Nov. 1987
Avail: NTIS HC A21/MF A01 CSCL 22B

The organization of orbital servicing of satellites is discussed. Provision of servicing equipment; design interfaces between the satellite and the servicing equipment; and the economic viability of the concept are discussed. The proposed solution for satisfying customer concerns is for the servicing organizations to baseline an adequate inventory of servicing equipment with standard interfaces and established servicing costs. With this knowledge, the customer can conduct tradeoff studies and make programmatic decisions regarding servicing options. A dialog procedure between customers and servicing specialists is outlined. ESA

N88-19506# Technische Hochschule, Darmstadt (West Germany). Dept. of Control Engineering.
A KNOWLEDGE-BASED APPROACH FOR SENSORY-CONTROLLED ASSEMBLY OPERATIONS
W. SIMON, E. ERSUE, and ST. WIENAND *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 185-190 Nov. 1987 Sponsored by Deutsche Forschungsgeimschaft
Avail: NTIS HC A21/MF A01

The approach for a knowledge-based robot operation system using different types of sensory information is presented. The system is intended for orbital assembly, maintenance, and repair tasks in a semiautomatic or automatic manner, using a general knowledge base. The components of this knowledge base are examined and a knowledge representation scheme based on a combination of rules and frames is proposed. A prototype of the approach implemented on a robotic hardware test bed is discussed for the part-mating problem. ESA

N88-19510# Central Research Labs., Red Wing, Minn.
REMOTE REPAIR DEMONSTRATION OF SOLAR MAXIMUM MAIN ELECTRONICS BOX
RICHARD H. ADAMS, ALAN E. GROSS, and CARLETON E. JENNRICH *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 227-232 Nov. 1987
Avail: NTIS HC A21/MF A01

The remote repair of the Solar Maximum satellite Main Electronics Box (MEB) using a master/slave servomanipulator is described. The MEB was not designed to be repaired on-orbit and represented the most difficult repair task performed by NASA astronauts. The viewing system, tooling, support equipment, and manipulator system used to perform the replacement sequence is presented. The technology demonstrations are described, along with guidelines for performing remote servicing. The remote servicing system demonstrates how tasks can be effectively performed on space vehicles in an unstructured or unfamiliar remote environment. ESA

N88-19528# International Technology, Washington, D.C.
REVIEW OF COMMERCIAL SPACECRAFT: RECOVERY AND REPAIR EXPERIENCES. IMPLICATIONS FOR FUTURE SPACECRAFT DESIGNS AND OPERATIONS
JOHN B. HIGGINBOTHAM *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 385-388 Nov. 1987
Avail: NTIS HC A21/MF A01

On-orbit salvage efforts on the Palapa B2, Westar 6 and Syncon 4 F3 spacecraft are discussed. Hughes Aircraft Company and NASA satellites were successfully recovered and returned to Earth or repaired with significant commercial benefits. Although both were successful, the repair mission shows higher financial returns without the added burden of remarketing or relaunching assets. Insurers learned that moderating losses arising from failures is not only possible, but can have significant impact on financial losses. To the extent that repair capability on-orbit can be enhanced and more certain, insurers can more readily consider this aspect in determining premium levels which should translate to lower insurance costs. Spacecraft designers should therefore bear in mind on-orbit servicing and repair from the outset. ESA

N88-19535# British Aerospace Public Ltd. Co., Bristol (England). Space and Communications Div.
EVA, THE TECHNOLOGICAL CHALLENGE
T. J. CARTWRIGHT and P. A. BLYTHE *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p

451-457 Nov. 1987
Avail: NTIS HC A21/MF A01

The technological challenge which must be overcome if man is to work outside the mother spacecraft is considered. Within the context of a space suit system hardware architecture the key requirements are discussed and a baseline subsystem design proposed for operations from the Hermes spaceplane. The technological issues and in particular the levels of technological maturity associated with this baseline are assessed in order to appraise the readiness of European industry to respond to extravehicular activity needs. With due consideration to the magnitude of the development required a plan is proposed for a European space suit system. Close consultation with U.S. and/or Soviet specialists is a possibility and technology transfer is addressed. ESA

N88-19541# Erno Raumfahrttechnik G.m.b.H., Bremen (West Germany).
EXTERNAL PAYLOAD SERVICING: OPERATIONAL REQUIREMENTS AND TECHNOLOGY
JUERGEN WEYDANDT, KLAUS-PETER LUDWIG, and HEINZ WARTENBERG *In* ESA, Proceedings of the 1st European In-Orbit Operations Technology Symposium p 501-510 Nov. 1987
Avail: NTIS HC A21/MF A01

The Orbital Replaceable Unit (ORU), EURECA, and Columbus Space Station are discussed as typical of trends in orbital servicing. It is shown that cost effective utilization of space platforms is provided by the low cost operation of a relatively small co-orbiting platform suited to 1000 kg payloads and 25 percent of the payload of a Space Shuttle (4200 kg) like EURECA. Frequent flight opportunities for external payload will be provided by on-orbit servicing. Servicing operations will start with low degree of serviceability and will be gradually increased with maturing servicing technologies. This will include remotely operated ORU exchange and complete payload element exchange or assembly. The GRASP orbital assembly mission planned by ESA will benefit from science carrier capabilities as well as from servicing techniques developed for on-orbit deployment of the large instrument. ESA

N88-19942# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Inst. for Aerospace Medicine.
IMPLICATIONS OF SHIFTWORK IN SPACE FOR HUMAN PHYSIOLOGY EXPERIMENTS
H. M. WEGMANN, A. GUNDEL, K. E. KLEIN, and A. SAMEL *In* ESA, Proceedings of the 3rd European Symposium on Life Sciences Research in Space p 255-258 Dec. 1987
Avail: NTIS HC A15/MF A01

The consequences of double-shift operations during Spacelab missions where crew members are required to work at unusual times of their habitual 24 hr cycles are discussed. In addition to this shift-work condition, astronauts are exposed to a zeitgeber ensemble that is substantially altered in comparison with their normal routine on Earth. Most likely, these two factors cause permanent changes in the circadian regulatory system. Computer simulations and extrapolations from jet-lag studies demonstrate that the instable circadian state may cause serious problems for human physiology experiments. ESA

17

SPACE ENVIRONMENT

Includes description of the space environment and effects on Space Station subsystems. Includes requirements for Space Station to accommodate this environment.

A88-16180#
RADIATION PROBLEMS WITH THE SPACE STATION SCENARIO AND THE NECESSARY SURVEILLANCE FOR ASTRONAUTS
J. U. SCHOTT and H. BUECKER (DFVLR, Institut fuer Flugmedizin, Cologne, Federal Republic of Germany) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 8 p. refs
(IAF PAPER 87-542)

Radiation problems in the typical orbits of Space Shuttle flights are discussed as well as problems with radiation surveillance in space radiation fields. A graph is presented of the LET spectrum of the D-1 mission (altitude 324 km, inclination 57 deg) and related quality factors. It is believed that the maximum stay in Space Station orbits might be limited to 20-30 days. An independent group focusing on an on- and off-line radiation surveillance for astronauts is expected to be established in the crew training center of the DFVLR. K.K.

A88-16183#
DYNAMICS OF ORBITING DEBRIS CLOUDS AND THE RESULTING COLLISION HAZARD TO SPACECRAFT
V. A. CHOBOTOV (Aerospace Corp., Los Angeles, CA) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 9 p. refs
(IAF PAPER 87-571)

The dynamics of a cloud of particles resulting from a breakup of an object in orbit is presented. Linearized equations of motion are used to obtain the shape and volume of the cloud as a function of time and the initial debris particle spread velocities. Spatial density is calculated for representative breakup models, and the probability of collision with a spacecraft in orbit is examined. The effects of earth's oblateness on the temporal evolution of the cloud are included. Author

A88-16186#
DEPARTMENT OF DEFENSE SPACE POLICY AND THE DEVELOPMENT OF A GLOBAL POLICY FOR THE CONTROL OF SPACE DEBRIS
L. PARKER TEMPLE, III (DOD, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 9 p. refs
(IAF PAPER 87-575)

In 1986, the U.S. Department of Defense conducted a study to determine whether the hazard potential to spacecraft from space debris was sufficiently great to warrant efforts to reduce any further contributions to existing debris levels. The hazard has been found to be serious; technologies supporting the implementation of a policy restraining additional debris growth have been identified. Attention is presently given to the pressing need for the development of global policy guidelines for space debris minimization. O.C.

A88-16378
MIR - SOVIET BASE IN SPACE
TIM FURNISS Flight International (ISSN 0015-3710), vol. 132, Oct. 17, 1987, p. 37-39.

The Soviet space station Mir is illustrated with photographs and drawings and briefly characterized. The history of the program is traced, emphasizing the modular design of Mir and its gradual buildup from components which are of essentially the same types as those in use in the Soviet space program for the last 15-20 yrs. Consideration is given to the solar panels, the core station, the Soyuz TM spacecraft which brings crew to and from Mir, the

docking facilities and procedures, the laboratory equipment, the service propulsion system, the LiOH air cleaners, the crew ascent/descent module, the Progress tankers, the Kvant physics facility, and future plans. T.K.

A89-10886* Alabama Univ., Huntsville.
A MEASUREMENT OF THE ANGULAR DISTRIBUTION OF 5 EV ATOMIC OXYGEN SCATTERED OFF A SOLID SURFACE IN EARTH ORBIT
JOHN C. GREGORY (Alabama, University, Huntsville) and PALMER N. PETERS (NASA, Marshall Space Flight Center, Huntsville, AL) IN: International Symposium on Rarefied Gas Dynamics, 15th, Grado, Italy, June 16-20, 1986, Proceedings. Volume 1. Stuttgart, B. G. Teubner, 1986, p. 644-654. refs
(Contract NAGW-812; NAS8-36189)

The angular distribution of 5 eV atomic oxygen scattered off a polished vitreous carbon surface was measured on a recent Space Shuttle flight. The experimental apparatus was of novel design, completely passive, and used thin silver films as the recording device for oxygen atoms. Most of the incident oxygen was contained in the reflected beam and remained in an active form and probably still atoms. Allowance was made for 12 percent loss of incident atoms which are converted to CO at the carbon surface. The scattered distribution which is wide lobular, peaking 15 deg in the forward direction, shows almost but not quite full accommodation. Author

A89-17944
ARTIFICIAL SPACE DEBRIS
NICHOLAS L. JOHNSON and DARREN S. MCKNIGHT Malabar, FL, Orbit Book Co., 1987, 120 p. refs

An account is given of the nature of anthropogenic debris in orbital space, and an evaluation is made of the hazards posed by its existence to future spacecraft. Attention is given to the deterioration and fragmentation of spacecraft in orbit, methods for the determination of debris size and dispersion, and the impact theory and debris models developed to date for the study of this phenomenon. Projections are made of debris hazards to geosynchronous satellites, and the degree of institutional awareness of the space debris problem. The possibility of this environment's cleaning-up in the future is discussed. O.C.

A89-18398
THE DANGERS OF SPACE DEBRIS - NEW DEVELOPMENTS AND DISCOVERIES [DIE GEFAHREN DER WELTRAUM-TRUEMMER - NEUE ENTWICKLUNGEN UND ERKENNTNISSE]
ELMAR VITT Zeitschrift fuer Luft- und Weltraumrecht (ISSN 0340-8329), vol. 36, Sept. 1987, p. 249-260. In German. refs

The current status of debris in earth orbit, the measures which could be undertaken to prevent further debris, and the legal implications of the debris problem are reviewed. Topics addressed include the rapid increase in the number of spacecraft being tracked, the fact that much larger numbers of untracked objects of cm and sub-mm size are also in orbit, and the relative contributions of accidental explosions and ASAT tests to the debris. Particular attention is given to the debris hazard for large structures such as the Space Station and for astronauts performing EVAs, the reentry of large satellite fragments (including radioactive materials from reactors), and the difficulties satellites and debris pose for astronomers. It is argued that present international agreements and regulations are inadequate to control debris or hold the producers of nonaccidental debris liable for subsequent damages. T.K.

A89-21091* McDonnell-Douglas Astronautics Co., Huntsville, Ala.
INTERMODULE VENTILATION STUDIES FOR THE SPACE STATION
ROY G. DAVIS (McDonnell Douglas Astronautics Co., Huntsville, AL) and JAMES L. REUTER (NASA, Marshall Space Flight Center, Huntsville, AL) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 13 p. refs
(Contract NAS8-36407)
(SAE PAPER 871428)

This paper examines the ability of the Space Station intermodule ventilation system to maintain centralized control of CO2 removal and O2 supply. The resulting concentration gradients that will arise are calculated by assuming steady state, ideal gas, isothermal conditions, and perfect mixing of air within and between the pressurized elements. In order to estimate the degree of mixing actually obtained for a given ventilation scheme, a program has been developed based on a potential flow solution technique. Preliminary results from this study indicate that substantial short circuiting and recirculation air flow patterns could arise if a simple duct and diffuser air exchange method at the docking port interface were employed. Author

A89-21131* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
ASSESSMENT OF EXTERNAL CONTAMINATION FOR SPACE STATION SCIENTIFIC PAYLOADS
GARY R. PRIMEAUX, MAURICE R. REUMONT, LUBERT J. LEGER (NASA, Johnson Space Center, Houston, TX), NANCY J. P. CAROSSO (NASA, Goddard Space Flight Center, Greenbelt, MD), RAYMOND L. GAUSE (NASA, Marshall Space Flight Center, Huntsville, AL) et al. SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 18 p. refs
(Contract NAS9-17133)
(SAE PAPER 871476)

This paper presents the analysis of the nature, the source, and the effect of contamination encountered by payloads external to the Space Station spacecraft. The contaminant modeling study determined the key contaminant sources for the Space Station payloads, together with the location, the duration, the major constituents of the contaminant, and the possibility of contaminant control. The next phase of the contamination modeling study investigates the compatibility of external Space Station payloads while on the transverse boom and the dual keel option. Other predictions include depositions on payload surfaces facing along +X, +Y, and +Z directions. An additional analysis will utilize the above data to predict the spectral brightness of the contaminants along payload lines-of-sight, making it possible for payload users to determine the impact of the contaminant background relative to the natural background. I.S.

A89-22323#
OBSERVATIONS OF IONS GENERATED ON OR NEAR SATELLITE SURFACES
C. W. NORWOOD, R. C. OLSEN (U.S. Naval Postgraduate School, Monterey, CA), and W. W. Li (California, University, La Jolla) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p. refs
(AIAA PAPER 88-0434)

Ion measurements with charged particle detectors on negatively charged spacecraft have revealed anomalous fluxes of low energy ions, at energies below the charging peak. These 'spacecraft generated ions' have been noted on ATS-5, ATS-6, ISEE-1, and P78-2 (SCATHA). On SCATHA, the measurements generally take the form of a shadow peak, at an energy below the main peak in flux associated with the satellite potential. Such peaks follow the satellite potential, for constant detector look angle. When the detector look direction is varied, the energy of the peak varies; minimum energies are observed tangential to the satellite body. Occasionally, a broad spectrum of ion fluxes is observed below the charging peak, as on ATS-5. The principle source appears presently to be sputtering from the satellite surface, although outgassing molecules ionized by photons or ambient particles may play a significant role. Author

A89-22919
RADIATION HAZARDS ON SPACE MISSIONS
JOHN R. LETAW (Severn Communications Corp., Severna Park, MD), REIN SILBERBERG, and C. H. TSAO (U.S. Navy, E. O.

Hulburt Center for Space Research, Washington, DC) Nature (ISSN 0028-0836), vol. 330, Dec. 24, 1987, p. 709, 710. Navy-DOE-supported research. refs

Calculations of the radiation dose equivalents to astronauts from Galactic cosmic radiation (GCR) and from energetic solar particle events are presented. Previous results identifying GCR as a significant factor in the space radiation dose are extended. In particular, the components of the radiation dose are determined, and the relationship between dose and shielding thickness is determined. Shielding requirements are proposed for future spaceflights. A storm shelter protected by at least 9 cm of aluminum or its equivalent is recommended for all spaceflights outside the magnetosphere. On long-duration flights, such as a Mars mission, all habitable spaces should be shielded with 7.5 cm aluminum or its equivalent. C.D.

A89-23930
RECONSTRUCTION OF THE VERTICAL ATMOSPHERIC TEMPERATURE PROFILE ON THE BASIS OF REFRACTION MEASUREMENTS FROM THE SALYUT-7 ORBITAL STATION [VOSSTANOVLENIE VERTIKAL'NOGO PROFILIA TEMPERATURY V ATMOSFERE PO IZMERENIIAM REFRAKTSII S ORBITAL'NOI STANTSII 'SALIUT-7']
A. A. VOLKOV, G. M. GRECHKO, A. S. GURVICH, V. KAN, and S. V. SOKOLOVSKII (AN SSSR, Institut Fiziki Atmosfery, Moscow, USSR) Akademiia Nauk SSSR, Izvestiia, Fizika Atmosfery i Okeana (ISSN 0002-3515), vol. 23, Nov. 1987, p. 1228-1230. In Russian.

A89-24846
DEBRIS HAZARD POSES FUTURE THREAT
RALPH D. LORENZ Spaceflight (ISSN 0038-6340), vol. 30, Jan. 1988, p. 4-7.

Space debris comprises three classes: particles, fragments, and artifacts; here the broad characteristics of these classes (such as mass, size, and composition) are listed in a table. The causes of spacecraft destruction are discussed, including antisatellite weapons system testing, self-destruction in order to prevent their impact on populated areas of the earth's surface, and the break-up of the nuclear power supplies of some satellites. Radar observations and computer models indicate that the worst position for the satellite is in an 800-km orbit with an inclination of about 120 degrees, and orbits from about 500 km to 1100 km are hazardous. Some of the more well-documented cases of spacecraft colliding with artificial space debris are analyzed. It is concluded that within 20 years or so it will be necessary to clear up at least some of the existing debris. The NASA Orbital Maneuvering Vehicle (OMV), which is able to reach some 2700 km above a Space Shuttle orbit, is discussed. A.S.

A89-28349
DETERMINATION OF COSMIC-RAY CHARACTERISTICS ON SALYUT-7 [OPREDELENIE KHARAKTERISTIK KOSMICHESKOGO IZLUCHENIIA NA ORBITAL'NOI STANTSII 'SALIUT-7']
A. B. AKOPOVA, V. E. DUDKIN, O. N. KARPOV, L. V. MELKUMIAN, IU. V. POTAPOV et al. Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 26, Jan.-Feb. 1988, p. 162-165. In Russian. refs

Long-term nuclear-emulsion measurements were carried out on Salyut-7 in an effort to determine cosmic-ray characteristics. It is shown that the technique used makes it possible to measure the linear-energy-loss spectrum over a long exposure period. Rare events with large linear energy losses (greater than about 10,000 MeV/cm) could be measured. B.J.

A89-28623
ELECTROSTATIC ANALYZERS DESIGN FOR SPACE INVESTIGATION
E. P. SAVOV (B'lgarska Akademiia na Naukite, Tsentralna Laboratoriia za Kosmicheski Izsledvaniia, Sofia, Bulgaria) Bolgarskaia Akademiia Nauk, Doklady (ISSN 0366-8681), vol. 40, no. 12, 1987, p. 33-35. refs

Electrostatic analyzers maintaining certain potentials are described according to their geometry as cylindrical, spherical, toroidal, etc., and are used in energy, mass, and angular analyses of charge particle flows in the ambient space plasma. It is presently shown that general relationships exist between device geometry and the parameters of the electrostatic analyzers. These relationships are applicable to the design of electrostatic analyzers for spacecraft-borne experiments. O.C.

N88-10851*# Aerospace Corp., El Segundo, Calif.
THE COMBINED RELEASE AND RADIATION EFFECTS SATELLITE, A JOINT NASA/DOD PROGRAM
D. J. BERRIER *In* NASA- Goddard Space Flight Center, Greenbelt, Md. Fourteenth Space Simulation Conference: Testing for a Permanent Presence in Space p 249-255 1986
Avail: NTIS HC A19/MF A01 CSCL 22B

The Combined Release and Radiation Effects Satellite (CRRES) program is a two-phase joint USAF/NASA program consisting of a low Earth orbit (LEO) phase and a geosynchronous transfer orbit (GTO) phase. The mission has been carefully planned to help clarify the geospace environment picture and its effects on space hardware, communications, and man. CRRES instruments were selected for synergism, accuracy, and applicability, and will be cross-calibrated for consistency. They will provide data to fill the gaps in geospace modeling data already obtained, and will update and correct existing models. The chemical release experiments and low altitude instruments will clarify the character of the ionosphere in low Earth orbit and the high altitude chemical release experiments will improve knowledge of how trapped particle populations behave out as far as synchronous altitudes. The ionospheric studies will lead to significantly improved Earth-space intercommunications. Author

N88-10859*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION CONTAMINATION CONSIDERATIONS Abstract Only
L. LEGER, H. EHLERS, and S. JACOBS *In* NASA- Goddard Space Flight Center, Greenbelt, Md. Fourteenth Space Simulation Conference: Testing for a Permanent Presence in Space p 341 1986
Avail: NTIS HC A19/MF A01 CSCL 22B

The external induced environment generated by space station activity, or more specifically by gases, particles, and light background is discussed. These contaminant species must be controlled if sensitive systems, such as solar energy collectors or science experiments exposed to the external environment are to function properly. The requirements generally set limits on the level of gas species, matter deposited on surfaces and light background levels over various spectral regions. They also address environment monitoring and contamination controls during manufacturing. Limits on effluent release and system leakages are in turn derived from these requirements. Author

N88-10860*# TRW, Inc., Redondo Beach, Calif.
CONTAMINATION CONTROL CONCEPTS FOR SPACE STATION CUSTOMER SERVICING
K. A. MARUYA, L. E. RYAN, L. A. ROSALES, and E. H. MEDLER *In* NASA- Goddard Space Flight Center, Greenbelt, Md. Fourteenth Space Simulation Conference: Testing for a Permanent Presence in Space p 342-366 1986
Avail: NTIS HC A19/MF A01 CSCL 22B

The customer servicing operations envisioned for the space station, which include instrument repair, orbital replacement unit (ORU) changeout, and fluid replenishment for free-flying and attached payloads, are expected to create requirements for a unique contamination control subsystem for the customer servicing facility (CSF). Both the core space station and the CSF users present unique requirements/sensitivities, not all of which are currently defined with common criteria. Preliminary results from an assessment of the effects of the CSF-induced contamination environment are reported. Strategies for a comprehensive contamination control approach and a description of specific hardware devices and their applicability are discussed. Author

N88-11702 Centre National d'Etudes Spatiales, Toulouse (France).
SPACE ENVIRONMENT TECHNOLOGY
Apr. 1987 751 p Partly in FRENCH and ENGLISH Lecture course presented in Toulouse, France, Apr. 1986
(ISBN-2-85428-170-5; ISSN-0766-1002; ETN-87-90631) Avail: CEPADUES-Editions, Toulouse, France

Lectures presented at the conference are presented. Areas of discussion are: Space plasma physics; the solar wind; and solar terrestrial interactions. Earth orbital environment, spacecraft charging and electrostatic discharges, and satellite design to overcome environmental effects were also discussed.
ESA

N88-11719 Centre d'Etude Spatiale des Rayonnements, Toulouse (France). Dept. d'Etudes et de Recherches en Technologie Spatiale.
EXTERNAL SURFACE CHARGING MECHANISMS
LEON LEVY *In* CNES, Space Environment Technology p 441-457 Apr. 1987 In FRENCH; ENGLISH summary
Avail: CEPADUES-Editions, Toulouse, France

Absolute and differential charging on geosynchronous satellites is introduced. It is the consequence of particle injection associated with substorm development. The importance of conductivity and secondary emission for the behavior of electron bombarded dielectrics is emphasized. An environment worst-case depending on material properties is discussed.
ESA

N88-11723 Centre d'Etude Spatiale des Rayonnements, Toulouse (France). Dept. d'Etudes et de Recherches en Technologie Spatiale.
DISCHARGE PHENOMENA
LEON LEVY *In* CNES, Space Environment Technology p 523-543 Apr. 1987 In FRENCH; ENGLISH summary
Avail: CEPADUES-Editions, Toulouse, France

The different ways of discharging likely to occur on satellite external surfaces are divided into two large categories: dielectric and metallic discharges. For each category, breakdown criteria are indicated.
ESA

N88-14090*# Northeastern Univ., Boston, Mass. Dept. of Chemical Engineering.
RAMAN SPECTRA OF ADSORBED LAYERS ON SPACE SHUTTLE AND AOTV THERMAL PROTECTION SYSTEM SURFACE Final Report
RONALD J. WILLEY *In* NASA. Lyndon B. Johnson Space Center, Houston, Tex. NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 2 22 p Nov. 1987
Avail: NTIS HC A15/MF A01 CSCL 22B

Surfaces of interest to space vehicle heat shield design were struck by a 2 W argon ion laser line while subjected to supersonic arc jet flow conditions. Emission spectra were taken at 90 deg to the angle of laser incidence on the test object. Results showed possible weak Raman shifts which could not be directly tied to any particular parameter such as surface temperature or gas composition. The investigation must be considered exploratory in terms of findings. Many undesirable effects were found and corrected as the project progressed. For instance, initial spectra settings led to ghosts which were eliminated by closing the intermediate of filter slit of the Spex from 8 to 3 mm. Further, under certain conditions, plasma lines from the laser were observed. Several materials were also investigated at room temperature for Raman shifts. Results showed Raman shifts for RCC and TEOS coated materials. The HRSI materials showed only weak Raman shifts, however, substantial efforts were made in studying these materials. Baseline materials showed the technique to be sound. The original goal was to find a Raman shift for the High-temperature Reusable Surface Insulation (HRSI) Reaction Cured borosilicate Glass (RCG) coated material and tie the amplitude of this peak to Arc jet conditions. Weak Raman shifts may be present, however, time limitations prevented confirmation.
Author

N88-15084# Battelle Inst., Frankfurt am Main (West Germany).
ALLOWABLE GRAVITY-LEVELS FOR SPACELAB, COLUMBUS AND EURECA Final Report
D. LANGBEIN Paris, France ESA Apr. 1987 206 p (Contract ESA-6726/86-F-FL-(SC))
(BF-R-66.525-2; ESA-CR(P)-2454; ETN-88-91150) Avail: NTIS HC A10/MF A01

The sensitivity of liquid columns to residual accelerations; oscillations of a spherical particle inside an oscillating spherical container; stability of Marangoni flows; critical phenomena; buoyancy effects associated with gravity disturbances; and tolerable g-levels for fluid science experiments in space are discussed.
ESA

N88-19934# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Inst. for Aerospace Medicine.
RADIATION PROBLEMS IN MANNED SPACE FLIGHT WITH A VIEW TO THE SPACE STATION
G. REITZ, H. BUECKER, and R. FACIUS *In* ESA. Proceedings of the 3rd European Symposium on Life Sciences Research in Space p 209-214 Dec. 1987
Avail: NTIS HC A15/MF A01

Gaps in knowledge and abilities which must be closed for an effective and economic realization of a space radiation protection concept are discussed. This includes the accurate determination of the components of the complex field of cosmic ionizing radiation, the proper evaluation of the biological importance of its densely ionizing component and of the depth dose distribution of the less penetrating component, the establishment of adequate radiation protection standards and of a system of dosimetric surveillance, as well as studies into the possibilities to harden selectively the Space Station or parts of it against components of cosmic radiation.
ESA

18

INTERNATIONAL

Includes descriptions, interfaces and requirements of international payload systems, subsystems and modules considered part of the Space Station system and other international Space Station activities such as the Soviet Salyut.

A88-10878
COLUMBUS TAKES SHAPE - EUROPE'S SPACE STATION APPROACHES DECISION TIME
CHRIS BULLOCH Interavia (ISSN 0020-5168), vol. 42, Sept. 1987, p. 975-978.

The designs and concepts for the main components of the Columbus project are analyzed. The current design for the Attached Pressurized Module, which is to be utilized for materials and life sciences experiments, is four tubular elements each 3m long and 4.06m in diameter, with a total length of 12.7 m and a mass of 15.5 tons. The experimental rack concept, crew space, and servicing and resupplying of the module are examined. The various payloads that could be attached to the outside of the module are discussed. The modules, applications, and servicing of the man-tended free-flyer are described. Consideration is given to the servicing of the polar platform which is to operate at 850 km and be used for remote sensing and communications.
I.F.

A88-13444#
STATUS OF ONGOING GOVERNMENT-LEVEL NEGOTIATIONS ON SPACE STATIONS [STAND DER LAUFENDEN VERHANDLUNGEN AUF REGIERUNGSEBENE UEBER WELTRAUMSTATIONEN]
MINDIRIG R. LOOSCH (BMFT, Bonn, Federal Republic of Germany) *IN*: The commercial use of space stations: The legal framework of trans-Atlantic cooperation; International Colloquium,

Hanover, Federal Republic of Germany, June 12, 13, 1986, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 15-26. In German.

Legal aspects of ESA participation in the NASA Space Station are discussed from a European perspective. The provisions of the ESA resolutions of January 31, 1985 are reviewed, and the importance of equal partnership in the development, construction, operation, and exploitation of the Space Station is stressed, recalling disputes regarding Spacelab. Consideration is given to legal safeguards in case of conflicts with national legislation; the differences among treaties, congressional executive agreements, and executive agreements in U.S. constitutional law; specific provisions on financing, services, and technology transfer; the overall structure of the agreement being considered; and the relationship of ESA to the other international partners (Canada and Japan). T.K.

A88-12446#
THE APPLICABLE LEGAL REGIME FOR INTERNATIONAL COOPERATION ON SPACE STATIONS
STEPHEN GOROVE (Mississippi, University, University) IN: The commercial use of space stations: The legal framework of trans-Atlantic cooperation; International Colloquium, Hanover, Federal Republic of Germany, June 12, 13, 1986, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 37-61. refs

The creation of a useful legal regime governing international cooperation on space stations is examined. The basic characteristics and functions of the proposed NASA earth-orbiting Space Station are described. The bilateral agreements between the U.S. and Canada, Japan, and ESA for the proposed design and development of the Space Station, in particular the U.S.-ESA Memorandum of Understanding, are discussed. The need for government-to-government agreements to handle issues such as jurisdiction, control, and registration of the Space Station; proprietary rights; and technology transfer is studied. Consideration is given to the relevance of domestic law and general international regulations; telecommunication issues; the transportation of hazardous materials; and the use of nuclear power. I.F.

A88-13449#
LEGAL PROBLEMS IN THE CONSTRUCTION OF SPACE STATIONS [RECHTSPROBLEME BEIM BAU VON WELTRAUMSTATIONEN]
HERMANN ERSFELD (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) IN: The commercial use of space stations: The legal framework of trans-Atlantic cooperation; International Colloquium, Hanover, Federal Republic of Germany, June 12, 13, 1986, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 88-117. In German.

Legal questions which could arise during the construction of the International Space Station are discussed from a European perspective. Topics addressed include the differences between treaties and executive (e.g., NASA-ESA) agreements under U.S. law; the registration, jurisdiction, and control of space objects (as defined under United Nations agreements); property rights; and regulation of the obligations undertaken by the Space Station partners. Consideration is given to the responsibilities of the partners for their own components and astronauts, technology transfer and information sharing, access without discrimination to U.S. installations, waiver of import and export limitations and duties, patent questions during transport to space and aboard the Space Station, and liability and insurance questions. T.K.

A88-13569#
ADVANCED MATERIALS FOR ESA SPACECRAFT
B. D. DUNN (ESA, Materials and Processes Div., Noordwijk, Netherlands) (World Conference on Advanced Materials for Innovations in Energy,Transportation and Communications, Tokyo, Japan, May 17-22, 1987) ESA Journal (ISSN 0379-2285), vol. 11, no. 2, 1987, p. 153-166. refs

Some of the new materials being employed by ESA for improving spacecraft hardware are reviewed. The general requirements for spacecraft materials are discussed. Advanced materials, such as fiber-reinforced plastic composites, metal alloys, and metal-matrix composites, for structural applications, mechanical devices, propulsion systems, and electronics are described, and examples of applications of these materials are given. Consideration is given to paints, lubricants, and joining techniques. I.F.

A88-14368
USSR EXPORT POSSIBILITIES IN THE FIELD OF SPACE HARDWARE
VLADIMIR PODSADNIK (Glavkosmos, USSR) SAE, Aerospace Vehicle Conference, Washington, DC, June 8-10, 1987. 7 p. (SAE PAPER 871342)

After presenting the pertinent performance capabilities of the Soviet Proton space launch vehicle, attention is given to such additional Soviet spacecraft systems possessing commercial value to Western business and government concerns as the Meteor earth resources satellite, the Mir orbiting space station, and various satellite launching and communication satellite leasing services. Also discussed are the parameters to be observed by foreign space experiment designers who wish to make use of the laboratory facilities aboard both unmanned Cosmos satellites and the Salyut manned space station for materials science-related researches. O.C.

A88-14911
SPUTNIK'S HEIRS - WHAT THE SOVIETS ARE DOING IN SPACE
PETER PESAVENTO Technology Review (ISSN 0040-1692), vol. 90, Oct. 1987, p. 26-35.

An account is given of Soviet nonmilitary manned and unmanned space program exploits that often go unnoticed in the Western news media despite their recent public availability, in the wake of the newly instituted policy of glasnost. The year 1987 is especially noteworthy in virtue of having witnessed the launching of the Soviet superbooster 'Energia'. Unmanned missions scheduled for the late 1980s and the 1990s encompass probes to the asteroid belt, to Venus, to the moons of Mars, and to Mars itself. Cosmonauts from Mongolia, Vietnam, Cuba, France, and India have participated in the 'Intercosmos' manned missions based on the space station Mir. O.C.

A88-15279
FUTURE EUROPEAN GROUND SEGMENT
RAINER GRUEN and HORST MICHAELIS (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 25 p.

Future European space programs such as Eureca, Columbus, Hermes, Ariane 5, DRS, and scientific satellites will require a ground-based end-to-end operation and verification infrastructure of a new order of magnitude as compared with the existing ground infrastructure. Individual program needs and required user support ground segments exceed the tight budget frame available for the European space community. It is noted that investments are necessary for industrial development facilities to support the AIV phase, support facilities for development and operation, launch and landing facilities, operations facilities for mission and payload control, and payload data facilities for data dissemination, archiving, and retrieval. Cost reduction can be achieved by harmonizing the ground segment, common developments and reusable investments, as well as by rationalizing the industrial capabilities. B.J.

A88-15293
COLUMBUS SPACE SEGMENT DEFINITION
SAMI GAZEY (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) and FRANK LONGHURST (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 18 p.

This paper describes the Columbus Space Segment definition process as implemented by European industry during Phases B1 and B2 in response to the requirements established by the European Space Agency. The development of the overall industrial structure during these phases is described, together with key roles and responsibilities. The approach being followed by industry to establish and implement the necessary management functions and procedures required by the European Space Agency to ensure adequate visibility and control of the program are also addressed, as are key technical and managerial aspects related to commonality and overall system coherence. Author

A88-15294
DEVELOPMENT OF THE RESOURCE MODULE FOR THE EUROPEAN SPACE STATION PROGRAMME COLUMBUS
IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 19 p.

The evolution of the Columbus resource module during the B1 and B2 study phases from July 1985 to May 1987 is summarized. Attention is given to the establishment of a design concept that is supposed to be the most flexible with respect to changing mission scenarios and different applications of the module. The development of the design itself is also shown with emphasis on the present reference configuration. The various configurations are depicted in a number of figures. B.J.

A88-15295
ENHANCED EURECA CONFIGURATION/OPERATIONS
WOLFGANG NELLESSEN (ESA, Noordwijk, Netherlands) and JUERGEN VON DER LIPPE (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 6 p.

The European Retrievable Carrier is currently undergoing its development phase. The Eureca payload for its first mission is primarily dedicated to the field of microgravity sciences although it also carries astrophysics experiments and technological experiments in the field of electrical propulsion and intersatellite communications in the kA band region. Since the concept of a small retrievable carrier offers the advantage of frequent and economical reflight, ESA has initiated a number of studies which proved the usefulness and flexibility of the Eureca concept to support basic research and technology development activities in various scientific and technical disciplines. This paper summarizes the results of the various studies performed so far and reports on the major characteristics of the proposed enhancement to the present carrier concept which are intended to be implemented on the second flight model of Eureca which is to be procured as part of the Columbus program. Author

A88-15296
MTFF OPERATIONAL DESIGN FEATURES
H. FRIEDRICH (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) and A. J. THIRKETTLE (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 18 p.

This paper describes the main design features incorporated in the European Space Agency's Man-Tended Free Flyer which enable the MTFF to be operational on-orbit for a 30 year period via servicing and maintenance. The MTFF is to be serviced at the Station or by Hermes every six months in one of two ways - using man in the Pressurized Module (PM) and using robotics for the external equipment of the PM and the Resource Module. EVA is a contingency back-up to the latter. Crew servicing inside the PM is enhanced by the proper attention to design details allowing good access to the payload and subsystem equipment in the same manner as for the Attached Modules of the Station, that is by mounting all equipment in standard racks to which the crew have easy access. Servicing of the external items is achieved by mounting them in Orbital Replacement Units (ORU's) which are compatible with the Station and/or Hermes manipulator arms. The ORU's have standardized interface provisions for end effectors and also for attachment to their parent spacecraft. There are also nonstandard ORU's such as solar arrays and comms antennae. The MTFF has attitude/orbit control, stability and position features, RVD sensors and propulsive capabilities for orbit maintenance, transfer and rendezvous functions. Author

A88-15297
THE COLUMBUS SYSTEM BASELINE AND INTERFACES
FRANK LONGHURST (ESA, Noordwijk, Netherlands) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 20 p.

The paper traces the evolution of the Columbus system baseline up to the present time and describes the most significant changes introduced into this baseline as a result of the definition process itself and as a consequence of changes introduced into other major systems with which Columbus has major external interfaces. It is noted that the definition process for the Columbus system is now reaching a critical stage, with convergence to a specific set of flight element configurations a high-priority objective, to allow the depth of definition required to enter into the development phase of the program. In addition, in several areas the definition of the external interfaces to other major systems under parallel definition is not yet very mature and requires sepcial emphasis. It is concluded that the studies performed to date have created a very comprehensive data base, which will ease the task of convergence once major program decisions are made. B.J.

A88-15298
COLUMBUS: ATTACHED PRESSURIZED MODULE CONFIGURATION - MTFF PRESSURIZED MODULE CONFIGURATION
L. D'EMILIANO (Aeritalia S.p.A., Turin, Italy) and A. J. THIRKETTLE (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 11 p.

The main technical features of the Columbus Attached Pressurized Module are described. Its internal configuration is a doubly symmetric cross section of four identical rack envelopes separated by standoffs carrying utilities. Its purpose is to provide resources for materials, fluid, and life sciences payloads for over a 30-year lifetime. The on-orbit payload accommodation is for up to 10,000 kg housed in up to 25 cu m of rack volume, with 10 kW power and 100 mbits/sec data transfer. Also described is the Columbus Man-Tended Free Flyer (MTFF) Pressurized Module. Being highly common with the Columbus Attached Module, it has system and subsystem architectures which will be very similar to those of the Station Modules. B.J.

A88-15476
NATIONAL SPACE ENGINEERING SYMPOSIUM, 2ND, SYDNEY, AUSTRALIA, MAR. 25-27, 1986, PREPRINTS. VOLUMES 1 & 2
Symposium sponsored by the Institution of Engineers, Australia and AUSSAT. Barton, Australia/Brookfield, VT, Institution of Engineers, Australia/Brookfield Publishing Co. (National Conference Publication, No. 86/3), 1986, p. Vol. 1, 325 p.; vol. 2, 327 p. For individual items see A88-15477 to A88-15527.

Papers are presented on such topics as Aussat development and operations; the Australia Telescope Project; Australian ground reception facilities for ERS 1; the Australian Landsat station at X-band; satellite lightwave communications; laser solar power satellites; Australia and the regulation of the geostationary orbit; Project Endeavor; and Quasat. Consideration is also given to technical and economic aspects of small digital earth stations; earth station antennas for multiple satellite access; the Mirrabooka X-ray detector and spacecraft design study; the ITU space conference; an Australian international business satellite

communications system; an Australian thin route satellite communication system; and a hydrogen scramjet with sidewall injection. B.J.

A89-15850
RESULTS OF MEDICAL INVESTIGATIONS CONDUCTED ABOARD THE 'SALYUT-6'-'SOYUZ' ORBITAL RESEARCH COMPLEX [REZUL'TATY MEDITSINSKIKH ISSLEDOVANII VYPOLNENNYKH NA ORBITAL'NOM NAUCHNO-ISSLEDOVATEL'SKOM KOMPLEKSE 'SALIUT-6' - 'SOIUZ']
N. N. GUROVSKII, ED. Moscow, Izdatel'stvo Nauka, 1986, 400 p. In Russian. No individual items are abstracted in this volume.

The results of medical tests investigating the health status of the Salyut-6-Soyuz spacecrew during the flight and after landing are presented. Consideration is given to changes found in various physiological systems, metabolic processes, sensor system functions, intestinal microflora, psychological status, and work capacity. The conditions of the space-station cabin, such as the atmosphere, microclimate, water supply, and chemical and microbial contamination, are discussed together with measures suggested to alleviate unfavorable effects of space flight and cosmic raysn. Special attention is given to the Intercosmos program, developed to coordinate the space-flight-related experiments planned by the participating-country members. The program's activities in the areas of radiation safety, the selection and training of cosmonauts, the development of the instruments for the evaluation of cosmonaut physiological and psychological reactions are discussed together with the results of these investigations during multinational flights. I.S.

A89-15803#
THE IN-ORBIT TECHNOLOGY DEMONSTRATION PROGRAMME OF THE EUROPEAN SPACE AGENCY
G. G. REIBALDI (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 10 p.
(IAF PAPER 87-03)

An increasing number of advanced space technologies require in-orbit demonstration as the final stage in their development before they can be integrated, without excessive risk, into new projects or embraced by industry in commercial ventures. To cope with those needs, ESA has already initiated the first phase (1987-1990) of its In-Orbit Technology Demonstration Program (TDP). This Program will extend well into the 1990s, as envisaged in the European Long-Term Space Plan, with a steadily increasing number of in-orbit tests being conducted each year. Such in-orbit testing reduces the risk element in more complex missions and provides European industry with the rapid flight testing of components and subsystems that it needs to compete in world markets. The content, status and planning of the present and future TDP phase shall be presented. Author

A89-15812#
EUROPEAN POLAR PLATFORM OPERATIONS AND LOGISTICS
W. JOHNSON (British Aerospace, PLC, Bristol, England) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 11 p.
(IAF PAPER 87-15)

This paper defines the European Polar Platform mission phases and the operations required in each of these in order to achieve the mission objectives. The constraints on the Platform and the limitations on life/growth due to the performance of the service vehicle are examined. It is found that it is feasible to launch a Platform carrying a payload in excess of 2500 Kg and maintain it over a period of 30 years by servicing it with the Shuttle every three years. It is also found that Platform propulsion systems which allow some forward loading of propellant enable the full service vehicle upload capability to be utilized every service and greater operational flexibility. Author

A89-15821#
EURECA - AN EXPERT SYSTEM FOR THE MANAGEMENT OF EXPERIMENTS TO BE PERFORMED ON A FREE-FLYING PLATFORM
R. CAPOBIANCHI, A. E. FINZI, and M. SOMALVICO (Milano, Politecnico, Milan, Italy) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 8 p. refs
(IAF PAPER 87-29)

The architecture and capabilities of an expert system developed for the management of crystal growth experiments to be conducted on the EURECA (European Retrievable Carrier) free-flying platform are reviewed. The knowledge representation model used is a production-system model implemented using the OPS5 (Official Production System - version 5) language. The expert system's principal activities vary from fault diagnostics to the planning and execution of specialized tasks. The system has been designed for efficient performance under complete autonomy but can also run in nonautomatic situations, leaving control to earth station commands acquired from the platform's telecommunication system. V.L.

A89-15827#
A NEW ITALIAN PROPOSAL FOR A SPACE STATION ASSEMBLY AND SERVICING VEHICLE (ASMV)
E. VALLERANI, G. OELKER, and L. BASILE (Aeritalia S.p.A., Settore Spazio, Turin, Italy) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 5 p.
(IAF PAPER 87-37)

An Assembly and Servicing Manned Vehicle (ASMV) to be used for the construction and maintenance of the Space Station is proposed. The design and operation of the ASMV are described. The use of EVA or the ASMV to assemble the Space Station is examined. It is determined that the ASMV will provide better protection for the astronauts, require no preparation time, and require less of the astronaut's time. The ASMV is to have the following capabilities: walking on the Space Station structure and flying around it; the same pressurization as the Space Station; an automatic attitude control system; manual, programmable, or automatic rendezvous and docking capabilities; an autonomous gas propulsion system; and compatibility with the Shuttle and Space Station. Possible modifications to the vehicle to increase its capabilities are discussed. I.F.

A89-15841#
COLUMBUS, PRESENT PROGRAMME STATUS
F. ENGSTROEM and G. ALTMANN (ESA, Directorate of Space Station and Platforms, Paris, France) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 22 p.
(IAF PAPER 87-62)

The Columbus program includes Europe's contribution to the international Space Station. The status of the present activities is described in this paper. It includes a brief description of the candidate hardware elements - attached pressurized module, man-tended free-flyer, and polar platform. Also, an enhanced version of the baseline Eureca which is being considered as an earth-based co-orbiter is described. Attendant programmatic data are discussed using Europe's long-term aim of eventual autonomy as a back-cloth. The role of the potential users of Space Station elements is stressed in the paper and plans for ensuring good use of the new capabilities available are presented. Author

A89-15842#
JEM PRESENT PROJECT STATUS
Y. MORISHITA, N. SAITO, and M. SAITO (National Space Development Agency of Japan, Tokyo) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 7 p.
(IAF PAPER 87-63)

At the end of March, 1987, the two years of the Japanese Experimental Module (JEM) phase B activities, involving detailed preliminary design and advanced technology development, drew to a close. During the second half of phase B activities, a high

fidelity mockup of JEM and an earth gravity-functional model of its remote manipulator system were constructed. Technology development efforts encompassed an equipment airlock, a freon pump, an electrical conveyor, a CO2 removal unit, an equipment exchange unit, and the manipulator arm's main and fine segments, as well as its gripper. O.C.

A88-15845#
THE COLUMBUS SPACE SEGMENT
F. LONGHURST (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) and S. GAZEY (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 50 p.
(IAF PAPER 87-66)

The major space components of Columbus, the ESA contribution to the International Space Station, are described, taking their relationships to other ESA programs into account. The history of the Columbus program is reviewed; the features of the attached pressurized laboratory module, the man-tended free flyer, the polar platform, and the enhanced version of the European Recoverable Carrier (Eureca B) are examined; and the data-management subsystem (based on a local-area network) is characterized in detail. Extensive diagrams, drawings, and development timetables are provided. T.K.

A88-15846#
EVOLUTION TOWARDS AN AUTONOMOUS EUROPEAN MANNED SPACE INFRASTRUCTURE
M. GRIMARD and G. DEBAS (Aerospatiale, Les Mureaux, France) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 12 p.
(Contract ESTEC-6668-86/NL/PP)
(IAF PAPER 87-67)

An overview is given of the results of the ESA Study Towards European Autonomous Manned Spaceflight (STEAMS). The general scope and assumptions of STEAMS are reviewed, and five possible missions for a European manned space station infrastructure are identified and discussed, involving materials sciences, life sciences, astronomy and astrophysics, earth observation, and technology. Two basic scenarios for the evolution of such a space station are summarized, and a description is given of the space station's building and use. The transportation segment based on the Ariane 5 and the Hermes spaceplane is addressed, and the escape vehicle is described. C.D.

A88-15849#
AUTOMATION AND ROBOTICS TECHNOLOGY APPLICATION TO JEM
M. SAITO, K. SHIRAKI, I. IIZUKA, and T. YOSHIOKA (National Space Development Agency of Japan, Tokyo) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 6 p.
(IAF PAPER 87-74)

Japan's contribution to the Space Station program will be the Japanese Experiment Module in which various space utilization experiments will be performed. In the present paper, consideration is given to the application of automation and robotics technologies to JEM. The JEM is composed of a pressurized module, an exposed facility, and an experiment logistics module. The automation and robotics technology can be used to increase JEM productivity, reduce the operation cost, improve the reliability/availability, eliminate perilous conditions, and perform tasks unsuited to crew. K.K.

A88-15850#
MAN TENDED FREE FLYER INTERIOR EQUIPMENT FOR MANNED AND AUTOMATED OPERATION
H. SIEMANN (Dornier System GmbH, Friedrichshafen, Federal Republic of Germany), G. HIRZINGER (DFVLR, Cologne, Federal Republic of Germany), and E. SCHMIDT (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 5 p.
(IAF PAPER 87-75)

The man tended free flyer (MTFF), part of the European Space Station program Columbus, is an orbiting laboratory operated by AI systems and robots. The MTFF is visited semiannually by astronauts aboard Hermes. In effect, the MTFF interior equipment has to be accessible to both man and machine. Germany has undertaken a robotics technology experiment (Rotex) to be flown on the Spacelab D-2 mission to verify robot technology for MTFF. Rotex operation will begin with functional verification involving the calibration of sensors, plant parameter verification, and the measurement of static and dynamic performance. The handling of a biological experiment, assembly of a truss structure, and the capture of a free-flying object are among the handling tasks to be performed. K.K.

A88-15853#
LONG-TERM EVOLUTION TOWARD EUROPEAN MANNED SPACEFLIGHT
U. RIEDEL (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) and C. COUGNET (Matra, S.A., Division Espace, Toulouse, France) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 11 p. ESA-supported research. refs
(IAF PAPER 87-78)

Results of a feasibility study of the long-term evolution toward European manned spaceflight are summarized. The study has, in principle, proven the feasibility of a long-term evolution that is based on the presently planned Columbus operational scenario, and indicates the inherent growth potential of the Columbus concept, aiming at European permanent manned Space Station. Future mission requirements, concepts for an atonomous Space Station, and program implementation options are discussed. V.L.

A88-15857#
TRADES AND PROBLEMS IN THE DEFINITION OF THE COLUMBUS OPERATION CONCEPT
GIUSEPPE GIAMPALMO (ESA, Columbus Operations Office, Paris, France) and JOCHEN GRAF (ESA, Columbus Operations and Software Div., Nordwijk, Netherlands) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 7 p.
(IAF PAPER 87-83)

The rationale, criteria, and resulting concepts associated with Columbus/Space Station operations are described. The European approach is the decentralization of operations for the following reasons: (1) the use of existing facilities, (2) the use of expertise and know-how where it resides, and (3) the possibility of retaining a clean task-oriented share of responsibilities with minimum interfaces and interferences. Specific operation functions are described such as tactical planning, system operations, payload operations, and crew utilization. K.K.

A88-15858#
THE BEGINNING OF THE MIR STATION ACTIVE OPERATION
IU. P. SEMENOV (AN SSSR, Institut Kosmicheskikh Issledovanii, Moscow, USSR) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 4 p.
(IAF PAPER 87-84)

The design and operation of the Mir station, which was placed into orbit on February 20, 1986, are examined and compared with those of the Salyut station. The Mir station consists of: (1) a core module, (2) scientific modules, and (3) transportation vehicles for both cargo and manned spacecraft. The functions and design of these components are described. Modifications to the Salyut design which have upgraded the Mir station are discussed. Particular consideration is given to the life support system (oxygen supply and CO2 removal); the attitude control system (gyrodyne); servicing and scientific equipment operation; the computer complex; and the communication system. I.F.

A88-15860#
COLUMBUS PRESSURIZED MODULES: MAINTENANCE AND SUPPLY CONCEPTS - APPROACH AND DEVELOPMENT FOR A SPACE STATION LONG TERM SUPPORT
VINCENZO DE FILIPPIS and GIUSEPPE MANCUSO (Aeritalia S.p.A., Turin, Italy) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 5 p.
(IAF PAPER 87-86)

The maintenance concepts for a manned space station with a continous 30-year mission are examined. To simplify the maintenonce tasks to be performed by the crew in the first phase of station operation, at which no special maintenance personnel will be allocated, use of the so-called orbital replaceable units (ORUs) is planned. An on-board videomonitor system is foreseen, which will include files, in digital optical format, to supply the technical information needed, with the use of bar codes allowing quick identification of the parts and quick retrieval of the instructions. The paper also discusses the data base composition, simulation of operations, and the supply concepts to support the maintenance and the environment of a space station. I.S.

A88-15861#
EXPERIENCE OF THE SALYUT-7 PROPULSION SYSTEM (PS) REPAIR OPERATIONS
V. S. OVCHINNIKOV (Moskovskii Aviatsionnyi Institut, Moscow, USSR) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 6 p.
(IAF PAPER 87-87)

The repair process of a leakage developed in one of the oxidizer pipelines of the Salyut-7 combined propulsion system (CPS) is described. In preparation of the repair, the tools, attachments, and a part of the assembly module were delivered to the station by the 'Progress' cargo vehicles, and the system was prepared by evacuation and purging of the CPS. The individual details of the procedures in the preparation, repair, restoration, and checking phases of the CPS repair operation are described. I.S.

A88-15865#
THE POTENTIAL OF COLUMBUS ELEMENT UTILISATION
J. J. DORDAIN (ESA, Directorate of Space Station and Platforms, Paris, France) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 10 p.
(IAF PAPER 87-94)

The objectives of the Columbus Utilization Program (CUP) are: (1) to identify the best uses of the Space Station elements, (2) to help and build up a Space Station user community, (3) to set up utilization procedures and strategies, and (4) to prepare the initial payload nissions. The three major categories for user experimentation (pressurized modules, unpressurized structures, and attached payloads) are discussed. The four phases of the CUP are outlined. K.K.

A88-15866#
PREPARATION OF SPACE STATION/COLUMBUS UTILIZATION
F. UNZ (DFVLR, Cologne, Federal Republic of Germany), B. DAVIES (Royal Aircraft Establishment, Space Dept., Farnborough, England), and F. ROSSITTO (Ministero per il Coordinamento della Ricerca Scientifica e Tecnologica, Rome, Italy) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 9 p. refs
(IAF PAPER 87-95)

As part of the Columbus preparatory program, Europe has been studying the utilization of the Space Station. Major findings for Columbus utilization are presented with attention given to the attached pressurized module (PM)/man-tended free-flyer (MTFF), the polar platform, the payloads attached to the core station, and Eureca-B. The need for highly automated facilities and laboratories to overcome limited crew availability on the PM and the absense of crew on the MTFF is demonstrated. K.K.

A88-15867#
ONE MISSION ON BOARD THE MIR SPACE STATION - THE FRENCH-SOVIET PROJECT ARAGATZ
M. ROUGERON (CNES, Paris, France) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 4 p.
(IAF PAPER 87-96)

The main objectives of the Aragatz mission are to study human physiology and to test new technology in orbit. The mission involves a 500-kg payload and 160 hrs of in-orbit working time. The possibilities offered by a manned orbital infrastructure are outlined. K.K.

A88-15873#
CONFIGURATION DRIVERS FOR THE EUROPEAN POLAR PLATFORM
P. TRUSS (British Aerospace, PLC, Space and Communications Div., Bristol, England) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 8 p.
(IAF PAPER 87-104)

The factors affecting the configuration of the ESA's Columbus Polar Platform are examined with particular reference to the payload mission, the spacecraft launch vehicle, the servicing method, and more general constraints. The reference requirements for the Polar Platform result in a spacecraft configuration that is very different from any preceding European program. The planned extended spacecraft lifetime and currently baselined associated servicing scenario are major configuration drivers; any major change would require a reassessment of the configuration design. V.L.

A88-15926#
CHALLENGE '95 - THE ARIANE 5 DEVELOPMENT PROGRAMME
M. VEDRENNE (ESA, Paris, France) and M. VAN GAVER (CNES, Toulouse, France) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 25 p.
(IAF PAPER 87-185)

The Ariane-5 launcher has been assigned to the following types of missions: (1) launching geostationary and sun-synchronous commercial satellites, and scientific and trial applications satellites; (2) launching the Hermes spaceplane, and (3) launching elements of the Columbus system such as the man-tended free-flyer module, and the polar platform. A new launch complex, the ELA-3, is being built for the Ariane-5 launcher close to ESA's ELA-1 and ELA-2 launch complexes at Kourou. After two qualification flights in the automatic version in 1995 (501 and 502), it is expected that Ariane-5 will be declared operational with its first commercial flight planned for early 1996 to put an automatic payload into orbit. K.K.

A88-15950#
SPACE STATION LOGISTIC SUPPORT BY ARIES
C. COUGNET (Matra Espace, Toulouse, France) and P. GROEPPER (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 10 p.
(IAF PAPER 87-222)

The architecture and functions of Aries, a low-cost expendable vehicle, are discussed. The Aries design is based on the Ariane 5 L5 and VEB. The major components of Aries are upgraded L5 and VEB and a payload adaptor; the design and operations of these components are described. The avionics and propulsion system for Aries are examined. Aries is to be employed for logistic support, assembly, and the placement of satellites. An example of a mission scenario and diagrams of Aries are provided. I.F.

A88-16050#
COLUMBUS PRESSURIZED MODULES - A CHALLENGING OPPORTUNITY FOR MICROGRAVITY RESEARCH AND APPLICATION
ENRICO BERUTO, GUALTIERO BRAMBATI, and ALFIO ALLEGRA (Aeritalia S.p.A., Settore Spazio, Turin, Italy) IAF, International

Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 29 p.
(IAF PAPER 87-375)

The key characteristic of the International Space Station (ISS) design is a controlled microgravity environment, which includes such aspects as the identification and description of all potential sources of disturbance; the definition and description of all structural paths; and the definition of characteristics and performance of isolation mounting devices to be inserted between the payload supporting structure and the payload equipment. In this paper, the analytical flow established to properly address the design of the Columbus Pressurized Modules (PMs), operating either as an integral part of the ISS (the attached Lab PM) or as a free-flyer (the man-tended free-flying Lab PM), is presented and discussed. Multiple diagrams are included. I.S.

A88-16054#
INTERIM FLIGHT OPPORTUNITY (IFO)
MARIE-HELENE AENISHANSLIN and PATRICK EYMAR (Aerospatiale, Les Mureaux, France) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 8 p.
(IAF PAPER 87-379)

Results of a study concerned with the IFO project, which involves a relatively simple facility that can be launched as a spare capacity or as main payload on different launchers into a variety of orbits, are reviewed. The study includes an analysis of the requirements induced by the payload needs, the launchers constraints, an overview of the exsiting hardware, and a preliminary analysis and design of the IFO system. Payload candidates, reentry constraints, selection of the reentry vehicle shape, a typical IFO mission, and the main design features of the system are discussed. V.L.

A88-16119#
THE DFS PLATFORM AND ITS APPLICATIONS
J. NAUCK and H. J. HEIDMANN (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 7 p.
(IAF PAPER 87-470)

The German 'DFS-Kopernikus' domestic communications satellite platform, scheduled for initial operations in 1989, is applicable to other missions and may be extended to meet increased future requirements. Attention is given to the various possibilities for FDS platform modification and extension that will yield a next-generation communications satellite. An important feature of the platform's design is its modularity, which divides service and communications functions; the communications module is further divided into repeater and antenna modules. Maximum launch mass is 1500 kg for a 10-year service life. O.C.

A88-16379
1986 - VERY GOOD YEAR FOR SOVIETS
NICHOLAS JOHNSON (Teledyne Brown Engineering, Colorado Springs, CO) Space World (ISSN 0038-6332), vol. X-10-286, Oct. 1987, p. 14-17.

Soviet space activities in 1986 are surveyed, summarizing the findings of the author's annual report (Johnson, 1986). Topics addressed include the approach to launch-vehicle technology (mass production of simple inexpensive hardware), the continuing success of the Mir manned space station, efforts to enter the global market for commercial launch services under the new space agency Glavkosmos, and increased propaganda efforts for a World Space Organization in the UN. Consideration is given to photographic-reconnaissance satellites, earth-resources missions, communication satellites, meteorological and remote-sensing satellites, the Vega mission to Comet Halley, and plans for solar-system exploration. T.K.

A88-16700
SOYUZ ENTERS THIRD DECADE
PHILLIP S. CLARK Space (ISSN 0267-954X), vol. 3, Sept.-Oct. 1987, p. 60, 61, 63, 64.

A history of the Soviet Soyuz manned spacecraft program is presented. When Soyuz 1 was launched in April, 1967, it was announced that extensive scientific and physiological experiments would be conducted. The flight ended in a crash and the death of the lone crewmember, but it has been surmised that it was to have docked with a Soyuz 2 that remained unlaunched. In subsequent years, Soyuz was redesigned to operate as a crew ferry vehicle for space stations such as Salyut in LEO, begining in 1971. Soyuz will remain operational until a Soviet space shuttle-type vehicle becomes available for manned missions. O.C.

A88-18223
JAPAN - FUTURE SPACE SAMURAI?
CHRIS BULLOCH Space Markets (ISSN 0258-4212), Fall 1987, 1987, p. 117-130.

The prospects for Japan's role in space are assessed. The administrative structure of the Japanese space program is described, and the autonomous state it will attain with the H-II launcher scheduled to fly in 1992 is addressed. Japanese space research projects are examined, including those based on the Spaceplane. The Japanese role in the International Space Station is discussed, and Japanese activities in satellite-based telecommunications and broadcasting are examined. C.D.

A88-18699
ENDURANCE RECORD BROKEN
NEVILLE KIDGER Spaceflight (ISSN 0038-6340), vol. 29, Nov. 1987, p. 373-377.

Progress 30 in flight is described as well as the Kvant module, EVA from Mir, and working on Mir. The Soyuz TM-3 international mission, Soviet/Syrian work in space, the descent to earth, and the redocking of Soyuz TM-3 are also discussed. The activities of Romanenko and Aleksandrov in August are reported. K.K.

A88-18700
SOVIET SHUTTLE FOR SPACE STATION ROLE
LUCIEN VAN DEN ABEELEN Spaceflight (ISSN 0038-6340), vol. 29, Nov. 1987, p. 378, 379.

Past and future trends in Soviet space hardware are reviewed with emphasis placed on the current transition to a new era of space exploration. The three 'parent' spacecraft designed by the Soviets (Vostok, Soyuz, and Salyut) are described in detail as well as Mir. While Mir relies on old technology, Energia and the Soviet shuttle represent space hardware of a truly new design. Due to eight boosters and an adapted core with third stage and payload on top, Energia is capable of putting modules with a diameter of 8-m and a mass of up to 200 tons into orbit. K.K.

A88-19826
NEW SPACE PRIORITIES IN THE USSR
ALAIN DUPAS (CNES, Paris, France) Space Policy (ISSN 0265-9646), vol. 3, Nov. 1987, p. 274-276. refs

Selected aspects of recent Soviet space activities are briefly discussed. Topics addressed include the 4000-tonne-thrust Energia launcher and its cryogenic second stage, the 5-yr test program for Energia and the Shuttle-type vehicle being developed to service the Soviet space station Mir, possible military applications of Energia and Mir, the increased emphasis being placed on the use of Soviet-made high-technology products, and the relationship between the new space activities and the current policy of political and economic restructuring. T.K.

A88-19835
THE COLUMBUS PROGRAMME - EUROPEAN STEPS TOWARDS THE CONSIDERED DEVELOPMENT OF NEAR-EARTH SPACE
PHILIP CHANDLER (DVFLR, Cologne, Federal Republic of Germany) Space Policy (ISSN 0265-9646), vol. 3, Nov. 1987, p. 335-339.

The components of the ESA Columbus program are briefly described, indicating their development status as of fall 1987. The

primary aims of Columbus are (1) to create an autonomous European infrastructure for manned space activities and (2) to contribute to the NASA-sponsored International Space Station. The components include a man-tended free flying pressurized laboratory coorbiting with the core Space Station, a Spacelab-based laboratory module attached to the core Station, an unmanned earth-observation platform in polar orbit, and the Shuttle-retrievable science platform Eureca B. It is argued that the development of Columbus must be carefully coordinated with that of other major ESA systems (the Ariane 5 launcher, the Hermes space plane, and the Data Relay Satellite) if goal (1) is to be achieved. T.K.

A88-20054
THE SOVIET SPACE FLIGHT PROJECT MIR [DAS SOWJETISCHE RAUMFLUGUNTERNEHMEN MIR]
UWE ZELTWANGER Astronautik (ISSN 0004-6221), vol. 24, July-Sept. 1987, p. 82-84. In German.

Aspects of the Soviet MIR Space Station project are discussed. The launch of the Station is reviewed, and the docking maneuver is described. Cosmonaut activities aboard the Station are discussed along with the nature of the experiments being performed there. C.D.

A88-20457
THE HIGH-FLYING KVANT MODULE
J. KELLY BEATTY Sky and Telescope (ISSN 0037-6604), vol. 74, Dec. 1987, p. 599-601.

The detection of X-rays from Supernova 1987A by instruments aboard the Soviet Kvant spacecraft is discussed. The Kvant module is 19 feet long and 13.6 feet across at its widest. On board are four telescopes for X-ray detection (TTM, gas-scintillation proportional counter, high-energy X-ray experiment, and Pulsar X-1) collectively weighing about 1,800 lbs. It is noted that observations are usually limited to the 20-min periods when Mir is over the equatorial region. K.K.

A88-21093
COLUMBUS ECLSS
H.-P. LEISEIFER and H. PREISS (Dornier System GmbH, Friedrichshafen, Federal Republic of Germany) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 5 p.
(SAE PAPER 871430)

An account is given of the design features and performance requirements of the environmental control and life support system (ECLSS) envisioned for the ESA Columbus program's Attached Pressurized Module (APM) and Man-Tended Free Flier (MTFF). Since the APM is designed to function only as a working habitat, the ECLSS requirements for its crew of three will be accommodated by the NASA Space Station. The ECLSS for the MTFF module will by contrast provide all functions required by a three-man crew during a twice-yearly seven-day sojourn. O.C.

A88-21138
THERMAL CONTROL DEFINITION OF COLUMBUS PRESSURIZED MODULES
GIUSEPPE D. RACCA and LAZZARO COSTAMAGNA (Aeritalia S.p.A., Settore Spazio, Turin, Italy) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 10 p. ESA-supported research.
(SAE PAPER 871483)

The requirements driving the thermal control design of the Columbus pressurized modules are discussed. Thermal control design trade-offs include single versus dual loop concepts, single versus two phase loop, loop arrangements, and radiator panel type. A common design concept is presented for both pressurized modules; water loops are utilized in the manned area of the modules, while freon R114 loops are employed in external areas to collect the heat from the water loop and feed the heat rejection system. K.K.

A88-21251
EURECA - EUROPEAN USER-FRIENDLY RETRIEVABLE CARRIER
K. SOMMER and W. KOEHLER-NAUMANN (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) Acta Astronautica (ISSN 0094-5765), vol. 15, Sept. 1987, p. 621-626. refs

The European retrievable carrier Eureca is planned to be launched by the NASA Space Shuttle for a six- to nine-month mission in low earth orbit. This paper discusses the Eureca applications and system capabilities, the scientific instruments to be carried for measuring solar physics and the properties of stars and space particles, the functional interfaces, user data management, and the ground support infrastructure. Special attention is given to the flight costs of Eureca consecutive missions. I.S.

A88-21252
THE COLUMBUS ATTACHED PRESSURIZED MODULE - SYSTEM AND MANAGEMENT ASPECTS OF INTERNATIONAL COOPERATION
ROMANO BARBERA (ESA, Directorate of Space Station and Platforms, Paris, France) Acta Astronautica (ISSN 0094-5765), vol. 15, Sept. 1987, p. 627-633.

The technical and management interfaces between the Space Station and the European Attached Pressurized Module are described. An overview is given on the mechanical, thermal, environmental control and life support, electrical power, data management, communication and operational interfaces as well as on the management interfaces on system and subsystem level and in the operation and utilization domains. The paper describes the status of the APM interface design as reflected by the Phase B-2 activities, which are subject to further definition during the progress of the technical work. Author

A88-21254
CENTRAL PROCESSING UNIT FOR FAULT TOLERANT COMPUTING IN COLUMBUS
MATS SVENNINGSSON (Saab Space AB, Goteborg, Sweden) Acta Astronautica (ISSN 0094-5765), vol. 15, Sept. 1987, p. 661-665.

One of the subsystems common to all three elements in the Columbus Space Station program is the Data Management Subsystem, DMS. The DMS is based on distributed computers conencted through a Local Area Network, LAN. In general the DMS is required to withstand one internal failure and still work in a full operational mode. This means that all equipment will at least be duplicated. The computers have to have a very high error self-detection coverage since no external equipment is available for this purpose. A failing computer will shut down itself after an error has been detected. The other computers on the LAN are then responsible for the reconfiguration. This paper will in general describe the fault tolerance concept proposed for the Columbus DMS and in particular detail the method to achieve the high error self-detection coverage in the computers. Author

A88-21256
EUROPEAN RETRIEVABLE CARRIER EURECA SERVICING BY HERMES
L. KERSTEIN, J. DETTMER, and W. RATH (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) Acta Astronautica (ISSN 0094-5765), vol. 15, Sept. 1987, p. 713-718. Sponsorship: European Space Research and Technology Centre.
(Contract ESTEC-6594/86/NL/PR)

The results of a mission definition study for in-orbit servicing of an Eureca-type platform by Hermes spacecraft are analyzed. The 'servicing' concept comprises the Hermes approach maneuver, the proximity operation, the capture and berthing process of the spacecraft to the servicing facilities, the actual servicing activities, the refueling operation, and the deployment and activation of the spacecraft for subsequent mission. The study demonstrated that the Hermes is capable of performing the servicing missions of the

Eureca-type spacecraft. The in-orbit operations and maneuvering with a small spacecraft like Hermes with an overall mass of 12.5 t can be kept to a minimum. The direct insertion of Hermes into the Eureca operational orbit provides the advantage of reducing the Eureca operations, so that the refueling for a two-year science mission will be not required. I.S.

A88-21524#
THE EURECA CONCEPT AND ITS IMPORTANCE IN PREPARING THE COLUMBUS PROGRAMME
R. D. ANDRESEN and W. NELLESSEN (ESA, Space Station and Platforms Directorate, Noordwijk, Netherlands) ESA Bulletin (ISSN 0376-4265), no. 52, Nov. 1987, p. 57-67.

The overall Eureca concept is described, and scientific research proposals for Eureca are examined. The potential Eureca technology demonstration mission is examined with emphasis on interorbit communications demonstration, rendezvous and docking demonstration, and in-orbit servicing. The development of a user-friendly Eureca utilization program is considered along with cost/efficiency considerations. It is concluded that the Eureca system can be regarded as a major potential stimulant and contributor to the preparations for the Space Station and its utilization program. B.J.

A88-21555
THE COLUMBUS PROGRAMME
F. ENGSTROEM (ESA, Space Station and Platforms Directorate, Paris, France) (Columbus II; Proceedings of the Second Workshop, Hanover, Federal Republic of Germany, June 9-11, 1986) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 7, no. 1-2, 1987, p. 7-17.

A critical point has been reached in the preparational phase of the Columbus Program. This corresponds to the end of phase B1 when ESA, on behalf of its member states, indicated to NASA its candidate Space Station elements for further study in phase B2. The ESA proposal contains the following suggestions for hardware participation in the international Space Station: (1) a pressurized module permanently attached to the Space Station; (2) a man-tended free flying (pressurized module + resource module); (3) a polar platform, and (4) a co-orbiting platform. This paper addresses programmatic aspects of Columbus, providing background for the selection of the proposed European candidates and giving a brief description of each. A possible scenario for the development program is presented and the Columbus elements are viewed as an integral part of an overall Space Station plan for Europe. The content of the necessary agreements between Europe and the U.S. are reviewed and some future operational issues are highlighted. Author

A88-21556
THE COLUMBUS SYSTEM ASPECTS
ANTS KUTZER (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) (Columbus II; Proceedings of the Second Workshop, Hanover, Federal Republic of Germany, June 9-11, 1986) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 7, no. 1-2, 1987, p. 19-32.

Technological and organizational aspects of the ESA Columbus program are reviewed, with a focus on the aims and preliminary results of phase B studies. Extensive drawings, diagrams, and tables of numerical data are provided, and consideration is given to the scope of the Columbus system, the overall management approach, cost projections, and critical commonality issues and interface requirements. T.K.

A88-21557
COLUMBUS PRESSURIZED MODULE
ERNESTO VALLERANI (Aeritalia S.p.A., Gruppo Sistemi Spaziali, Turin, Italy) (Columbus II; Proceedings of the Second Workshop, Hanover, Federal Republic of Germany, June 9-11, 1986) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 7, no. 1-2, 1987, p. 33-56.

The design and deployment configurations of the Spacelab-based Pressurized Module (PM) components of the ESA Columbus program are presented in extensive drawings, diagrams, and photographs and discussed in detail, summarizing the results of the phase B study. Present plans call for both (1) a Shuttle-launchable four-segment PM to be part of the scrubbed-down figure-of-eight dual-keel configuration of the Space Station core and (2) an Ariane-launchable two-segment PM as the basis for the Man-Tended Free Flyer (MTFF); the dimensions and weight of the PMs require that they be launched empty, with standardized payload components (Orbit Replacement Units) to be installed (and later exchanged) on orbit. Consideration is given to the arrangement of the PM racks, the four-corners utilities setup, the main PM subsystems and their distribution, payload accomodations, the MTFF design concept, and the construction of a full-scale (three-segment) PM mockup. T.K.

A88-21558
THE COLUMBUS POLAR PLATFORM
F. E. SAWDON, P. J. CONCHIE, and R. M. SHELTON (British Aerospace, PLC, Space and Communications Div., Bristol, England) (Columbus II; Proceedings of the Second Workshop, Hanover, Federal Republic of Germany, June 9-11, 1986) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 7, no. 1-2, 1987, p. 57-66.

The European Polar Platform is one of the elements being studied under contract to the European Space Agency as part of the Columbus program which is being conducted in parallel with the United States Space Station program. This paper presents requirements, design aspects and cost-effectiveness of a polar orbiting platform carrying Earth Observation instruments. The platform is serviceable, which allows replacement of life-limited or failed components, replenishment of consumables, technology update and payload growth. Over a period of 10 years, the payload power requirement grows from 5 to 10 kW, mass from 2.4 to 5 tonnes, and data rate from 300 M bits per s to 500 M bits/s. The platform is designed in three major sections, a propulsion module, a utilities section and the payload section. The propulsion module contains sufficient propellant for boost from Shuttle delivery orbit to operational orbit, deboost from operational orbit to Shuttle service orbit, and a two-year orbital stay period. The cost effectiveness of servicable platforms is compared withthat of nonmaintainable spacecraft. Under the criteria of payload mass carrying capability, payload power provision and payload data transmission the platform is considerably more effective than expendable spacecraft. Author

A88-21559
THE RESOURCE MODULE
G. H. RAUSCH and M. TOUSSAINT (Dornier System GmbH, Friedrichshafen, Federal Republic of Germany) (Columbus II; Proceedings of the Second Workshop, Hanover, Federal Republic of Germany, June 9-11, 1986) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 7, no. 1-2, 1987, p. 67-70.

The design and operation of the Columbus Resource Module (RM) are discussed, summarizing the results of phase B1 studies undertaken for ESA. The reference configuration of the RM comprises an orbital maneuvering section (including AOCS and propulsion system), a power section (400 sq m of solar panels providing 14 kW to payloads), and an orbital replacement section (accommodating payload modules). In the Space Station IOC, the RM will (1) be joined to (and provide utilities for) a two-segment version of the Columbus Pressurized Module to form the Man-Tended Free Flyer and (2) pick up payload carrier elements from the core Station to operate as a coorbiting platform; expanded RM functions are planned for the AOC. Consideration is given to the RM subsystems, operations and utilization, technology development, and growth potential (e.g., commonality with Columbus Polar Platform utilities and propulsion modules). T.K.

A88-21560
ELECTRICAL POWER FOR COLUMBUS - AN IMPORTANT CROSS-ELEMENT TASK
GERT EGGERS (AEG AG, Wedel, Federal Republic of Germany)

(Columbus II; Proceedings of the Second Workshop, Hanover, Federal Republic of Germany, June 9-11, 1986) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 7, no. 1-2, 1987, p. 71-80.

The results of R&D studies of electric power systems (EPSs) for the ESA Columbus program are discussed and illustrated with extensive diagrams and drawings. The three major EPS requirements for the Space Station IOC are (1) 8 kW (in both sun and shadow phases) for the Polar Platform, (2) 30 kW for the Pressurized Module when attached to the Station core, and (3) about 8 kW for the Man-Tended Free Flyer. The current EPS reference configuration is a 150-V dc system comprising a primary power assembly (solar array, power conditioner, and battery), a power distribution assembly, and power interface units (for the Space Station, the Shuttle Orbiter, Ariane, and Hermes). The effects of LEO on the EPSs are indicated, and the criteria to be considered in selecting established and new technologies for the major EPS assemblies are examined in detail. T.K.

A88-21561
FOKKER SUBSYSTEM RESPONSIBILITIES IN COLUMBUS B PHASE STUDIES

J. H. DE KOOMEN (Fokker, Amsterdam, Netherlands) (Columbus II; Proceedings of the Second Workshop, Hanover, Federal Republic of Germany, June 9-11, 1986) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 7, no. 1-2, 1987, p. 81-87.

The designs of the Polar Platform (PPF) and Resource Module (RM) solar arrays and the Pressurized Module (PM) equipment airlock for the ESA Columbus program are presented in extensive drawings and briefly characterized, summarizing the results of phase B studies. Both flexible 'roll-out' and rigid versions of the 16-kW 150-V dc solar arrays are being studied. Additional factors to be considered include commonality of design among PPF, RM, and enhanced Eureca; stowage volume and weight; rigidity; AOCS constraints; complexity and reliability; maintainability; the Orbital Replacement Unit philosophy, and cost. The equipment airlock is a self-contained unit of internal diameter 980 mm to be attached to an aperture of the PM and controlled from within. It is based on the Spacelab airlock but has electric-motor drive and must meet an unlimited lifetime requirement. T.K.

A88-21562
AEROSPATIALE STUDIES FOR IOC AND AOC

PATRICK EYMAR (Aerospatiale, Les Mureaux, France) (Columbus II; Proceedings of the Second Workshop, Hanover, Federal Republic of Germany, June 9-11, 1986) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 7, no. 1-2, 1987, p. 93-104.

Aerospatiale involvement in permanent manned LEO activities covers a wide range of topics from system studies to subsystems development including also some payload definition. This paper gives an overview of these activities, which encompass (1) system and operations aspects: interfaces between Columbus elements, Ariane 5, and Hermes (launch, retrieval, servicing and maintenance); (2) Columbus ancillary elements studies: definition of an Ariane Transfer Vehicle, of a man-tended servicing unit (Octupus) and of a Space Mail System; (3) Columbus elements subsystems: secondary structure for the pressurized modules, thermal control subsystem for the resource module of the Man-Tended Free Flyer, and thermal control with structure definition of the propulsion module of the polar platform; and (4) Columbus candidate payloads: heterodyne spectroscopy cornerstone mission, microgravity facility, and Anthrorack. Author

A88-21563
COLUMBUS OPERATION AND UTILIZATION

FABRIZIO PETROSINO (Telespazio S.p.A, Rome, Italy) (Columbus II; Proceedings of the Second Workshop, Hanover, Federal Republic of Germany, June 9-11, 1986) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 7, no. 1-2, 1987, p. 105, 106.

Activities being undertaken to facilitate the scientific and commercial utilization of the components of the ESA Columbus program are briefly reviewed. The need for greater cooperation between system designers and end users is stressed. Particular attention is given to preliminary results from a study of the requirements of European users for (1) space communication and navigation (SCN) payload accomodation, (2) SCN operating capabilities, (3) earth observations, and (4) payload information (a Columbus payload data base). T.K.

A88-21564
PRINCIPLES OF OPERATIONS COOPERATION BETWEEN THE UNITED STATES AND EUROPE

K. HEFTMAN (ESA, European Space Operations Centre, Darmstadt, Federal Republic of Germany) (Columbus II; Proceedings of the Second Workshop, Hanover, Federal Republic of Germany, June 9-11, 1986) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 7, no. 1-2, 1987, p. 107-112.

The International Operations Concept Working Group (IOCWG) developed the attached 'Level A Operations Management Concept' for the Space Station System. This document is the culmination of a year's effort starting in April 1985. The concept has evolved through many discussions and reviews by Space Station program offices at all NASA levels; by other NASA program offices and Field Centers; and by cooperating agencies in Europe (ESA), Japan, and Canada, who all provided the membership of the IOCWG. In the environment in which the concept will be applied a number of issues remain for resolution: e.g., the timing of the formation of an operations organization, decision rules at the strategic level, use of other launch vehicles, questions of ownership, and the scheme for the sharing of operations costs. The Concept is deemed sufficiently flexible to accommodate various alternatives. Ongoing work addresses the definition of an actual management structure, subsequent assignment of roles and missions to be performed, and discussion of remaining differences among the various cooperating agencies in the Concept document itself. The following May 6, 1986 version is then that issued by the NASA chairman of the IOCWG. Author

A88-21565
COLUMBUS UTILIZATION PREPARATION - STATUS OF ONGOING STUDIES

F. ROSSITTO (CNR, Rome, Italy) and F. UNZ (DFVLR, Cologne, Federal Republic of Germany) (Columbus II; Proceedings of the Second Workshop, Hanover, Federal Republic of Germany, June 9-11, 1986) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 7, no. 1-2, 1987, p. 127-132.

The organization of payload and utilization studies being undertaken in the framework of the Columbus Preparatory Program is outlined, and the current status is briefly indicated. Separate element-utilization studies are planned for the Pressurized Module and Man-Tended Free Flyer, the Polar Platforms, and the coorbiting platforms; payload studies will focus on a microgravity applications, space science facilities, earth observation, communication and navigation, and a technology demonstration mission. Preliminary recommendations for Pressurized Module utilization are presented in tables and diagrams. T.K.

A88-21567
SPACE SCIENCE WITH COLUMBUS

H. OLTHOF (ESA, Scientific Programme Directorate, Paris, France) (Columbus II; Proceedings of the Second Workshop, Hanover, Federal Republic of Germany, June 9-11, 1986) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 7, no. 1-2, 1987, p. 137-141.

The potential use of the different Columbus spacecraft for space science projects is examined, surveying the current status of ESA planning studies. The role of Columbus in the overall ESA science program is outlined; the capabilities of the individual Columbus components (Pressurized Module and Man-Tended Free Flyer, Polar Platform, and enhanced Eureca) are indicated; the transportation and on-orbit servicing capabilities of the Space Station are described; and particular attention is given to the Comet

Nucleus Sample Return and Submillimeter Heterodyne Spectroscopy missions as preselected cornerstones of the Columbus space science program. Additional projects in solar and terrestrial physics, astronomy, and environmental monitoring and small-to-medium-scale investigations suitable for Eureca are briefly characterized. T.K.

A88-21573 National Aeronautics and Space Administration, Washington, D.C.
INTERNATIONAL COOPERATION IN THE SPACE STATION
WILLIAM P. RANEY (NASA, Utilization and Performance Requirements Div., Washington, DC) (Columbus II; Proceedings of the Second Workshop, Hanover, Federal Republic of Germany, June 9-11, 1986) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 7, no. 1-2, 1987, p. 171-173.

The principles and policies governing participation in the International Space Station are examined from a NASA perspective. The history of the program is reviewed; the most important aspects of the partnership concept (functional allocation, shared access, and interface commonality) are considered in detail; and the ongoing outfitting studies are briefly characterized. Major issues remaining to be negotiated include (1) the overall management structure; (2) the division of responsibilities for system design, integration, operation, and utilization; and (3) the sharing of operating costs. T.K.

A88-21574
JAPAN'S CONTRIBUTION TO THE SPACE STATION PROGRAM
TADAHICO INADA (National Space Development Agency of Japan, Paris, France) (Columbus II; Proceedings of the Second Workshop, Hanover, Federal Republic of Germany, June 9-11, 1986) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 7, no. 1-2, 1987, p. 175-183.

The current reference configuration of the Japanese Experiment Module (JEM) for the International Space Station is presented in tables and drawings and briefly characterized. The history, principles, and objectives of Japanese participation in the program are reviewed; the industry members of the JEM study support team and their individual responsibilities are listed; and the subelements of the JEM are described, including pressurized module, exposed facility, experiment logisitics module, local manipulator, and science airlock. T.K.

A88-21575
PARTNERSHIP, A KEY ISSUE IN THE INTERNATIONAL SPACE STATION COOPERATION
MARIO DE LEO (Ministero per il Coordinamento della Ricerca Scientifica e Tecnologica, Rome, Italy) (Columbus II; Proceedings of the Second Workshop, Hanover, Federal Republic of Germany, June 9-11, 1986) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 7, no. 1-2, 1987, p. 185-189.

The organizational approach to be followed in implementing the ESA Columbus program for participation in the International Space Station is examined. The recent history of ESA-NASA negotiations is traced, and the present Columbus reference configuration is described. Possible organizational structures are presented in a series of block diagrams and briefly characterized. T.K.

A88-23516
PLANNING FRAMEWORK FOR HIGH-TECHNOLOGY SPACE FLIGHT (OHR) [ORIENTIERUNGSRAHMEN HOCHTECHNOLOGIE RAUMFAHRT (OHR)]
HARTMUT SAX (DFVLR, Cologne, Federal Republic of Germany) DFVLR-Nachrichten (ISSN 0011-4901), Nov. 1987, p. 2-6. In German.

The recommendations of OHR, a document published in 1987 by a DFVLR-led working group of FRG academic and aerospace industry representatives, are summarized. U.S. and Soviet long-term planning is evaluated, and it is urged that the FRG participate actively (through ESA) in both (1) the development of a European reusable space transportation system and (2) the NASA International Space Station. The OHR strategy emphasizes long-term commitment to technologies of key importance to future missions. According to OHR, at least 10 percent of FRG space funding should go to conceptional and technological preparation of future programs; applications, technology, and cost studies of ongoing and planned programs should be carried on continuously; and a broad future-oriented scientific and technological basis should be built up in the FRG. Specific DFVLR projects related to the OHR recommendations are listed, illustrated with drawings and photographs, and briefly characterized. T.K.

A88-23989#
FUTURE EUROPEAN GROUND SEGMENT
RAINER GRUEN and HORST MICHAELIS (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987, Paper. 29 p.
(MBB-UR-E-976-87)

The future of the European ground infrastructure for supporting future European space programs and scientific satellites is discussed. The problems of manpower and budget are reviewed. Planned European space flight demonstrations are summarized, and the present ground infrastructure is described. The future flight infrastructure for the Columbus, Ariane, Hermes, EDRS, Eureca, and various scientific, earth observation, and telecommunications satellites is examined. Finally, the future ground infrastructure for these missions and their harmonization and rationalization are addressed. C.D.

A88-23991#
MAN TENDED FREE FLYER UTILIZATION ASPECTS
KARSTEN HUSE (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987, Paper. 12 p.
(MBB-UR-E-981-87)

The ESA Columbus Man-Tended Free Flyer (MTFF) is described, with a focus on the kinds of experiments it will accomodate. The advantages of a free-flying configuration for certain types of research are outlined, and the possible role of the MTFF as the core of a future autonomous European space station is indicated. The MTFF comprises a two-segment (20-rack) version of the Columbus Pressurized Module and a Resource Module providing utilities and services; it is designed for Ariane 5 launch to a 450-km 28-deg circular boomerang orbit (centered on the Space Station orbit) and a 30-yr service life, based on a 180-day cycle for manned servicing from the Station. Particular attention is given to the material-science and life-science experiments selected for the MTFF reference mission, the high-quality MTFF microgravity environment, and the automated operation of MTFF between servicing visits. Diagrams, drawings, graphs, and tables of numerical data are provided. T.K.

A88-24793
INTERCOSMOS: AN EXAMPLE OF COOPERATION ['INTERKOSMOS' - ETO SOTRUDNICHESTVO]
IU. I. ZAITSEV, ED. Moscow, Izdatel'stvo Mashinostroenie, 1987, 256 p. In Russian. No individual items are abstracted in this volume.

A popular account of Polish-Soviet collaboration in the Intercosmos program is given. Particular consideration is given to experiments on Intercosmos-6 and Intercosmos-Copernicus-500 and to flights on Soyuz-30 and Salyut-6/Soyuz. B.J.

A88-24990#
CANADA'S SPACE STATION PROGRAM
K. H. DOETSCH (National Research Council of Canada, Ottawa) and J. A. MIDDLETON (Spar Aerospace, Ltd., Toronto, Canada) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 33, Dec. 1987, p. 218-223. refs

Canada will participate in the NASA Space Station Program not only through its contribution to the development and operation of facilities for the assembly, maintenance, and servicing of the Space Station, but also though the privileges extended to Canada

in the use of all capabilities of the Space Station's infrastructure. In the specific field of automation and robotics, Canada will contribute the Mobile Servicing System (MSS), which encompasses both ground and orbital elements; the latter include the Mobile Servicing Center, the MSS Maintenance Depot, and the Special Purpose Dexterous Manipulator. O.C.

A88-25943
REPAIR OF SALYUT 7
DENNIS NEWKIRK (Purdue University, West Lafayette, IN) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 3, Feb. 1988, p. 9-11. refs

The USSR's Salyut 7 space station, launched on April 19, 1982, has been used by several cosmonaut crews and the need has arisen for component repair and replacement to keep the station operating. In March 1985, it became clear that the Soviets hads lost control of Salyut 7 and that it drifted for months totally abandoned. Dzhanibekov and Savinykh's work in putting the space station back into working order under adverse conditions is described. K.K.

A88-26099
OBSERVATIONS OF OCEAN AND SEA BOTTOM RELIEF FROM SPACE [NABLIUDENIIA REL'EFA DNA MOREI I OKEANOV IZ KOSMOSA]
A. LAZAREV, V. KOVALENOK, T. DAMINOVA, and CH. VILLMANN (AN ESSR, Institut Astrofiziki i Fiziki Atmosfery, Tartu, Estonian SSR; Gosudarstvennyi Opticheskii Institut, Leningrad, USSR) Eesti NSV Teaduste Akadeemia, Toimetised, Fuusika-Matemaatika (ISSN 0367-1429), vol. 36, no. 4, 1987, p. 398-404. In Russian.

Visual observations of the bottom relief of the open ocean made by cosmonauts aboard the Salyut-6 orbital station are analyzed. Under certain conditions, it is possible to study the bottom relief at a depth of 100 meters. It is shown that agitation of the ocean does not significantly affect the possibility of observing submerged objects and formations whose angular dimensions exceed the resolving power of the cosmonaut's visual system. K.K.

A88-26170
ORBITAL SYSTEMS [ORBITALSYSTEME]
M. KUEBLER (Dornier System GmbH, Friedrichshafen, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 11, Nov.-Dec. 1987, p. 317-320. In German.

The technological history and current status of efforts to establish earth-orbit bases and infrastructure are reviewed from a European perspective. Consideration is given to the U.S. and Soviet programs based on expendable launchers, the NASA decision to develop the reusable Space Shuttle, and the gradual buildup strategy used in the Soviet Mir space station program. Particular attention is given to the International Space Station and the evolution of the ESA Columbus program, which aims to participate in the Space Station while establishing the technology base for autonomous European space activities. The current Columbus configuration includes a Pressurized Module (PM) for the core Station, an unmanned Polar Platform (primarily for terrestrial remote sensing), and an Ariane-launched Man-Tended Free Flyer (MTFF) comprising a PM and a resource module. Plans call for the ESA manned orbiter Hermes to be available to service the MTFF. T.K.

A88-27734
SPACE NEAR AND FAR [KOSMOS DALEKII I BLIZKII]
V. M. MESHKOV and Z. P. DZHINOVA Moscow, Izdatel'stvo Kniga, 1987, 96 p. In Russian. refs

This book comprises a bibliography of Russian-language works (including translations) on various aspects of space. Each bibliographical entry is accompanied by a brief note explaining why the work is recommended reading. Historical works are examined along with works dealing with the sociopolitical, scientific, and technological aspects of space exploration. B.J.

A88-27743
DEPLOYABLE UMBRELLA REFLECTOR ANTENNAS [RAZVERTYVAEMYE ZERKAL'NYE ANTENNY ZONTICHNOGO TIPA]
MIKHAIL VASIL'EVICH GRIANIK and VLADIMIR IVANOVICH LOMAN Moscow, Izdatel'stvo Radio i Sviaz', 1987, 72 p. In Russian. refs

Aspects of the design of axisymmetric and axially asymmetric deployable umbrella reflector antennas are examined. An electrodynamic analysis of one-reflector and two-reflector umbrella antennas is presented; techniques for enhancing the efficiency of umbrella antennas are described; and the radiation characteristics of such antennas are calculated. B.J.

A88-27952#
JAPAN TAKES CHARGE
NEIL W. DAVIS Aerospace America (ISSN 0740-722X), vol. 26, March 1988, p. 22-26.

Some proposed Japanese space projects are examined. The development of and funding for the H-2 orbital plane, the aerospace plane, and a space station are discussed. The H-2 orbital plane is to be 13 m long and 10-20 tons, have a wingspan between 9.2 and 12 m, wing areas of 40 sq m, a payload of 4 tons or less, and require 5 kW of continuous power. Attention is given to the planned satellite projects, which include the development of large multibeam satellites, an advanced earth observation satellite, an advanced geostationary meteorological satellite, and a space flyer unit. I.F.

A88-28856
THE EURECA SPACE PLATFORM [LA PLATE-FORME SPATIALE EURECA]
PHILIPPE MONTPERT (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) L'Aeronautique et l'Astronautique (ISSN 0001-9275), no. 126, 1987, p. 58-65. In French.

Characteristics of the Eureca space platform, projected to perform six months of experimentation in 1990, are discussed. The mission consists of shuttle launching, deployment at a 300 km orbit, transfer to its 525-km operational orbit, transfer to retrieval orbit, rendezvous with the shuttle, and landing. The energy storage, thermal control, data analysis, and attitude and control systems are considered in detail. It is pointed out that various aspects of the mission, including the rendezvous technology, its long duration in LEO, and the telemetering and remote guidance systems, have application to the European space station. R.R.

A88-29106
THE SPACE LIFE SCIENCES RESEARCH AND APPLICATION IN EUROPE
KARL E. KLEIN (DFVLR, Institut fuer Flugmedizin, Cologne, Federal Republic of Germany) IN: Biological sciences in space 1986; Proceedings of the 1986 International Symposium, Nagoya, Japan, Nov. 10-12, 1986. Tokyo, MYU Research, 1987, p. 17-24.

The space life sciences activities planned and implemented by ESA and by various West-European national space organizations focus on three domains: (1) the utilization of the space environment for basic reserach in space life sciences (LSs), (2) the development of technologies for the maintenance of physical and mental health of man in space, and (3) the utilization of microgravity for a potential commercial application. The past projects with European LS payloads on the USSR and the U.S. missions are discussed along with the LS payloads of future missions planned and the specific research activities to be carried out on these flights. I.S.

A88-29195
LONG-TERM STRATEGY OF SPACE SCIENCE IN JAPAN
M. ODA (Tokyo, University, Japan) (COSPAR, IAU, IUGS, et al., Plenary Meeting, 26th, Topical Meeting C3, Workshop III, and Symposium 8 on Planetary Studies, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 7, no. 12, 1987, p. 171-174.

The scientific satellites of Japan which have been launched

since 1970 and are scheduled for launch in the 1990s are discussed with respect to their characteristics, mission goals, and the highlights of the observations obtained by past missions. The strategy so far was to place emphasis on the frequency of the programs rather than on the scale of the mission. Future model missions for astronomy/astrophysics and solar systems science are discussed. The astronomy/astrophysics missions to be launched in the 1990s and the early 2000s will include four X-ray observatories, two IR missions, two solar physics observatories, and one each of gamma-ray, space VLBI, and UV missions. Mission models for solar systems science include satellites for investigating Venusian atmosphere, Jovian magnetosphere, solar wind, and the geomagnetic field. In preparation for planetary science in the 21st century, a lunar mission is planned for the mid 1990s. I.S.

A88-29245#
ON LOCAL STATE FEEDBACK AND STABILITY DOMAIN ESTIMATION OF NONLINEAR LARGE SCALE SYSTEMS
RUNYI YU and WEIBING GAO (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, Nov. 1987, p. A 597-A 604. In Chinese, with abstract in English. refs

In this paper, a linear quadratic design and a technique to define a quadratic Lyapunov function from the positive solution of N decoupled Riccati algebraic equations are used to stabilize nonlinear, time-invariant, large-scale systems by local state feedback and to determine the stability domain. For 'minimal strongly connected systems' and other systems with similar properties, the method is quite effective and the procedure is simple. The method gives better results than others with regard to the decentralized stabilization of a large-scale telescope. C.D.

A88-30078
STRATOSPHERIC LUMINESCENCE OBSERVED FROM THE SALYUT-7 STATION [SVECHENIE STRATOSFERNOGO SLOIA, NABLIUDAVSHEESIA NA ORBITAL'NOI STANTSII 'SALIUT-7']
G. M. NIKOL'SKII, M. BEL'MADI, V. V. BUTOV, E. S. VANIARKHA, V. A. DZHANIBEKOV (AN SSSR, Institut Zemnogo Magnetizma, Ionosfery i Rasprostranenila Radiovoln, Moscow, USSR; CNRS, Institut d'Astrophysique, Paris, France) et al. Issledovanie Zemli iz Kosmosa (ISSN 0205-9614), Nov.-Dec. 1987, p. 3-8. In Russian. refs

The mechanism of luminescence of a narrow stratospheric layer along the horizon is studied. This luminescence was observed on June 30, 1982 from the Salyut orbital station at moonset over the equatorial Pacific. The effect is shown to be due to moonlight scattering on aerosols supplied by the El Chichon eruption in the spring of that year. Author

A88-30115
ROTATION STABILITY OF A DEFORMABLE FLIGHT VEHICLE [OB USTOICHIVOSTI VRASHCHENIIA DEFORMIRUEMOGO LETATEL'NOGO APPARATA]
L. V. DOKUCHAEV Prikladnaia Matematika i Mekhanika (ISSN 0032-8235), vol. 52, Jan.-Feb. 1988, p. 25-33. In Russian. refs

The Lur'e (1961) approach and the Kane (1980) method are used to obtain general equations describing the motion of a liquid-filled elastic flight vehicle in orbit. By generalizing results of earlier studies, conditions are obtained for the asymptotic stability of the rotation of a flight vehicle with allowance for damping. The analysis is illustrated by an example. V.L.

A88-30189
COSMONAUTS OBSERVE SUPERNOVA
NEVILLE KIDGER Spaceflight (ISSN 0038-6340), vol. 30, March 1988, p. 113-117.

The record-breaking cosmonaut flight aboard the Mir space station, during which the SN 1987A supernova occurred, is described. The process of crew selection, the planning for the mission, the activities aboard Mir, and the return to earth are reviewed. The relations between the cosmonauts in space are addressed. C.D.

A88-30185
THE SOVIET COSMONAUT TEAM, 1978-1987
REX HALL British Interplanetary Society, Journal (Soviet Astronautics) (ISSN 0007-084X), vol. 41, March 1988, p. 111-116. refs

The crews who have flown missions in Soyuz-T and Soyuz-TM spacecraft starting in 1980 are considered. The new cosmonauts appointed in 1976-1978, the crews on Soyuz-T test flights, the Salyut 7 training group, visiting mission training groups, the operational Salyut 7 group, the second Salyut 7 residency, international missions in 1984, a visiting mission in 1984, and Salyut 7 operations in 1984 are covered. The crew involved in the rescue of Salyut 7 are cited, and the various Mir crews are given. C.D.

N88-10050# Joint Publications Research Service, Arlington, Va.
USSR REPORT: SPACE
22 Apr. 1987 166 p Transl. into ENGLISH from various Russian articles
(JPRS-USP-87-003) Avail: NTIS HC A08/MF A01

Topics addressed include: manned mission highlights; space sciences; interplanetary sciences; space policy and administration; launch table; and space applications.

N88-10051# Joint Publications Research Service, Arlington, Va.
BLAGOV COMMENTARY ON MIR STATION, FIRST MANNING
V. D. BLAGOV *In its* USSR Report: Space p 1-12 22 Apr. 1987 Transl. into ENGLISH from Zemlya i Vselennaya (Moscow, USSR), no. 6, Nov. - Dec. 1986 p 2-10
Avail: NTIS HC A08/MF A01

The Mir orbital station is the third generation of the Soviet orbital stations, on which complicated scientific and technical research and experiments were conducted in space for 15 years. The successful accomplishment of this complex flight demonstrated the high degree of reliability of Soviet space technology, of the methods for controlling the flight, the unlimited possibilities for further development and improvement, and for increasing the efficiency of scientific research. The launch of the Mir station laid the foundation for the establishment in orbit of permanently active, manned scientific research complexes. Scientific research on the Earth's natural resources and on astrophysical objects, as well as medicine and biology will assume permanency. The production of alloys and crystals, medicines free from allergens, and various biological preparations will gradually reach an industrial scale. The orbital complexes will consist of a large number of modules including ones flying apart from the base block and space tugs will make flights between the modules to service them. B.G.

N88-10052# Joint Publications Research Service, Arlington, Va.
X-RAY ASTRONOMY INSTRUMENTS TO OPERATE ON MIR STATION
TAMARA BREUS *In its* USSR Report: Space p 50-51 22 Apr. 1987 Transl. into ENGLISH from APN: Advances of Science and Technology (Moscow, USSR), no. 21, 5 Nov. 1986 p 1-3
Avail: NTIS HC A08/MF A01

The Soviet Salyut orbital stations were the first to carry X-ray telescopes into space. The Mir station offers still greater opportunities for astronomical observations by ensuring high guidance accuracy in the automatic regime. Even more important, it extends the period of observations without impairing other research programs. The X-ray telescopes will operate within a wide band of energies, making it possible to solve in principle astrophysical tasks unattainable for the available space-based telescopes. Equipment and instruments for the Mir X-ray observatory were developed and manufactured through the collective efforts of the Soviet Union, the Netherlands, West Germany, and the European Space Agency. The design and advantages of the telescope are discussed. B.G.

N88-10080# Aeritalia S.p.A., Naples (Italy). Gruppo Sistemi Spaziali.
COLUMBUS PREPARATORY PROGRAM. PAYLOAD ELEMENT STUDY ON A TECHNOLOGY DEMONSTRATION MISSION, EXECUTIVE SUMMARY
F. BORLASTA, F. GIANI, R. SOCK, H. FRIEDERICH, T. WIERENGA, and J. PAIROT (MATRA Espace, Paris-Velizy, France) Paris, France ESA 15 Dec. 1986 77 p
(Contract ESA-6614/85-NL-PP(SC))
(CS-RP-AI-016; ESA-CR(P)-2401; ETN-87-90556) Avail: NTIS HC A05/MF A01

The review, further definition, and preliminary conceptual design of four technology demonstration model missions for possible performance on the Columbus module of the United States Space Station are summarized. Guidelines for potential users and the Columbus study team concerning the design of cost effective and user friendly space infrastructure for technology missions are given. The four technology model missions investigated were: Robotic Servicing Experiment; Fluid Transfer Management System; Large Structure Deployment/Assembly; and Tether System. Two additional concepts were selected by ESA for consideration: European Space Technology Exposure Facility and Technology Workbench. ESA

N88-10205# MATRA Espace, Toulouse (France).
PRELIMINARY STUDY OF A GRAVITATIONAL BIOLOGY FACILITY FOR COLUMBUS, EXECUTIVE SUMMARY
Paris, France ESA 1986 174 p
(Contract ESA-6501/85-F-FL(SC))
(MATRA-EPT/AS/VT209/255/NT; ESA-CR(P)-2389; ETN-87-90522) Avail: NTIS HC A08/MF A01

The scientific and experimental background, scientific and experimental requirements, and a design concept and facility philosophy of a spaceborne biology laboratory were studied. Services required from the Columbus space station and peripheral units were assessed. Accommodation and operational aspects were investigated. ESA

N88-10842*# Aeritalia S.p.A., Rome (Italy).
COLUMBUS PRESSURIZED MODULE VERIFICATION
PIERO MESSIDORO and EMANUELE COMANDATORE *In* NASA-Goddard Space Flight Center, Greenbelt, Md. Fourteenth Space Simulation Conference: Testing for a Permanent Presence in Space p 113-148 1986
Avail: NTIS HC A19/MF A01 CSCL 22B

The baseline verification approach of the COLUMBUS Pressurized Module was defined during the A and B1 project phases. Peculiarities of the verification program are the testing requirements derived from the permanent manned presence in space. The model philosophy and the test program have been developed in line with the overall verification concept. Such critical areas as meteoroid protections, heat pipe radiators and module seals are identified and tested. Verification problem areas are identified and recommendations for the next development are proposed. Author

N88-10980# Societe Nationale Industrielle Aerospatiale, Paris (France).
METALLURGY LABORATORY FOR COLUMBUS, EXECUTIVE SUMMARY
H. SAINCT, F. JAMIN-CHANGEART, and J.-P. PRAIZEY Paris, France ESA Mar. 1987 15 p
(Contract ESA-6625/85-F-FL-SC)
(SNIAS-813-CA/TS; ESA-CR(P)-2416; ETN-87-90878) Avail: NTIS HC A03/MF A01

Three furnaces for directional solidification, artificial composites, and in situ composites for the Columbus space station microgravity environment are proposed. A gradient furnace limited to 1300 C, fully instrumented and dedicated to basic research can be accommodated in a single rack. The limited temperature leads mainly to gradient restrictions for materials with a good thermal conductivity (Al, Ag, Cu). A second, higher temperature gradient furnace, dedicated to applied research and preindustrial development, has a heating chamber with larger cavity and 2000 C maximum temperature. An isothermal furnace (2000 C maximum temperature and at least 100 mm sample diameter) is dedicated mainly to glass processes. To maximize the efficiency of such a furnace a positioning device may be implemented. The power needs of the last two furnaces are limited by the Columbus capacities, consequently they are accommodated in the same high-powered double rack and are run in sequence. ESA

N88-12135# European Space Agency, Paris (France). Legal Affaires Div.
LEGAL PROTECTION OF THE POLAR PLATFORM'S USERS
A. VAHRENWALD *In its* Commercial Opportunities for Remote Sensing with Polar Platforms p 27-34 Apr. 1987
Avail: NTIS HC A05/MF A01

Legal problems faced by the user of Columbus Polar Platforms for remote sensing are reviewed. International law, international law of outer space, the legal regime of the space station system, the U.S. Land Remote-Sensing Commercialization Act of 1984, copyright law, the law of unfair competition, and the legal obligations by which a user may attempt to bind purchasers are discussed. ESA

N88-12136# Hunting Technical Services Ltd., Borehamwood (England).
CONFIDENTIALITY OF DATA
J. W. TREVETT *In* ESA, Commercial Opportunities for Remote Sensing with Polar Platforms p 35-37 Apr. 1987
Avail: NTIS HC A05/MF A01

It is argued that exclusive rights to data are more important than confidentiality for the Columbus Polar Platform remote sensing observations. For the on-board instrumentation and the ground segment, normal patent and copyright laws protect both hardware and software developments. For the data, the open skies policy continues to apply and as with existing satellites, confidentiality will not be a problem. ESA

N88-12917# Joint Publications Research Service, Arlington, Va.
STUDY OF CERTAIN BIOLOGICAL CHARACTERISTICS OF BACTERIA DURING THE FRENCH-SOVIET CYTOS-2 SPACE EXPERIMENT
S. N. ZALOGUYEV, A. F. MOROZ, N. G. ANTSIFEROVA, L. I. GLATMAN, V. L. POPOV, V. K. ILYIN, F. M. KIRILLOVA, L. N. KATS, M. P. BRAGINA, and V. M. SHILOV *In its* JPRS Report: Science and Technology. USSR: Life Sciences p 2 5 Aug. 1987 Transl. into ENGLISH from Zhurnal Mikrobiologii, Epidemiologii i Immunobiologii (Moscow, USSR), no. 8, Aug. 1985 p 3-7
Avail: NTIS HC A06/MF A01

The major purpose of the studies reported in this article was to determine the antibiotic sensitivity of opportunistic microorganisms among the autoflora of astronauts by in vitro cultivation in orbital flight. Experiments were performed on the Salyut-7 spacecraft during a visit by a French astronaut utilizing S. aureus and E. coli isolated from the astronaut before the flight. Antibiotic sensitivity of the microorganisms was determined by double serial dilution. S. aureus were tested with oxacillin, chloramphenicol and erythromycin, E. coli--with kanamycin and colistin. The toxicity, immunogenicity and serotype membership of three strains of Pseudomonas aeruginosa were also determined. The antibiotic sensitivity of the microorganisms was found to be slightly higher under orbital conditions. Ultrastructural studies performed after the flight showed no significant morphologic changes in the E. coli, but some thickening of the cell walls, particularly in S. aureus. Characteristics of the P. aeruginosa were found to be stable and unaltered by space flight. Author

N88-13379# Consiglio Nazionale delle Ricerche, Frascati (Italy). Ist. di Fisica dello Spazio Interplanetario.
MECHANICAL DESIGN OF THE AC BRACKET PACKAGE FOR THE RETE EXPERIMENT [PROGETTO MECCANICO DELLA UNITA' ACBP PER L'ESPERIMENTO RETE]

P. BALDETTI and M. CANDIDI Feb. 1987 28 p In ITALIAN (IFSI-87-4; ETN-88-91291) Avail: NTIS HC A03/MF A01

An element placed at the extremity of the TSS5 satellite arm to explore the structure of the zone around the satellite was designed. The unit includes the search coil and electric antennas subsystems. The design specifications and the detailed mechanical design are presented. ESA

N88-15005# Aeritalia S.p.A., Naples (Italy). Space Systems Group.
COLUMBUS PRESSURIZED MODULE UTILIZATION STUDY, EXECUTIVE SUMMARY Final Report
R. BATE and M. MERLO Paris, France ESA 12 Jun. 1987 30 p
(CS-RP-AI-027; ESA-CR(P)-2460; ETN-88-91154) Avail: NTIS HC A03/MF A01

The optimum way to exploit the Columbus laboratories capabilities was defined by identifying and describing payload accommodation, integration, operations, mission planning, user support, and mission assurance and safety. A detailed plan for mission implementation was produced and preliminary associated costs were estimated. The payload and utilization derived requirements for both the overall Columbus system and its two pressurized modules were specified. ESA

N88-16063# Joint Publications Research Service, Arlington, Va.
JPRS REPORT: SCIENCE AND TECHNOLOGY. USSR: SPACE
24 Nov. 1987 175 p Transl. into ENGLISH from various Russian articles
(JPRS-USP-87-006) Avail: NTIS HC A08/MF A01

Articles from Soviet books and journals on the overall subject of space are translated and presented. The report is divided into subject areas: Manned mission highlights; Space sciences; Interplanetary sciences; Life sciences; Space engineering; Space applications; and Space policy and administration. Selected titles from these subject areas are presented.

N88-16365*# Messerschmitt-Boelkow-Blohm/Entwicklungsring Nord, Bremen (West Germany). Space Systems Group.
EUREX D: AN EXPERT SYSTEM FOR FAILURE DIAGNOSIS AND RECOVERY IN THE TCS OF THE EUROPEAN RETRIEVABLE CARRIER EURECA
A. KELLNER, W. BELAU, and N. SCHIELOW *In* NASA. Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 1 p 131-135 Nov. 1987
Avail: NTIS HC A18/MF A01 CSCL 09B

An expert system for diagnosis and recovery of failures in the Freon cooling loop of the European retrievable experiment carrier EURECA is described. The system demonstrates the feasibility of a functional scope of expert diagnostic systems which appears to be essential for practical applications of such systems in space technology. The scope includes early warning and treatment of incomplete information, fault tolerance, identification of failure superpositions, intelligent reaction to unforeseen events, and detailed status display for optimal recovery action. Author

N88-16767# European Space Agency, Paris (France).
ESA BULLETIN NO. 35
BRUCE BATTRICK, ed. and DUC GUYENNE, ed. Feb. 1981 86 p
(ISSN-0376-4265; ETN-87-90517) Avail: NTIS HC A05/MF A01

The ESA convention; satellite assembly in geostationary orbit; Meteosat photographs of Karman vortex streets in the atmosphere; the Ariane 3 program; solar simulation; satellite power transmission to Earth; parallel processing utilization for remote sensing image processing; and training in satellite ground system operations are discussed.

N88-16777# European Space Agency, Paris (France).
PROCEEDINGS OF THE ESA WORKSHOP ON CO-ORBITING PLATFORM ELEMENTS (COPE)
T. DUC GUYENNE, ed. Sep. 1987 71 p Workshop held in Noordwijk, Netherlands, 7-8 Apr. 1987 Original contains color illustrations
(ESA-SP-1093; ISSN-0379-6566; ETN-88-91413) Avail: NTIS HC A04/MF A01

Solid Earth, land, ocean, ice, and atmosphere observation from space; spaceborne space science; Columbus Space Station; and microgravity experiments were discussed. ESA

N88-16784# European Space Agency, Paris (France). Space Station and Platforms Directorate.
THE COLUMBUS PROGRAM, AN OVERVIEW
D. J. SHAPLAND *In its* Proceedings of the ESA Workshop on Co-Orbiting Platform Elements (COPE) p 61-67 Sep. 1987 Also presented at the ESOIR Workshop, Avignon, France, Jun. 1986
Avail: NTIS HC A04/MF A01

Columbus program candidate elements are described. The elements are a pressurized module/laboratory permanently attached to the Space Station core; a man-tended free flyer (pressurized module plus resource module); a polar platform; and a co-orbiting platform, based on EURECA. A scenario and schedule of events is discussed in the framework of a total European plan. The importance of user requirements is stressed and the handling of those needs is discussed. ESA

N88-16799# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).
COLUMBUS FEASIBILITY STUDIES. VOLUME 1: REQUIREMENTS AND SYSTEM CONCEPT Final Report
1986 506 p Sponsored by Bundesministerium fuer Forschung und Technologie/DFVLR and the PCB/MRST Prepared in cooperation with Aeritalia SpA, Turin, Italy and Dornier-Werke GmbH, Friedrichshafen, West Germany
(ETN-88-91073) Avail: NTIS HC A22/MF A01

The Columbus Space Station scenario, payload requirements, general system requirements, and design objectives are outlined. The system concept is described. The requirements are primarily driven by the interfacing system, i.e., the Manned Space Station (MSS), the Shuttle Space Transport System (STS) and the prospective payloads. Further requirements result from the inherent needs of the Columbus system itself, and from technical and operational constraints. The Columbus concept, in its initial phases, depends on U.S. resources like STS, MSS, and TDRS, but it is also adaptable to a potential future European space station with elements which are not yet in the Columbus scenario. This applies to the principal concepts of the elements and to the development of subsystem hardware and software. It is shown that the system concept meets design requirements. ESA

N88-16800# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).
COLUMBUS FEASIBILITY STUDIES. VOLUME 2: ELEMENT CONSTITUENTS, MECHANICAL Final Report
1986 351 p Sponsored by Bundesministerium fuer Forschung und Technologie/DFVLR and the PCN/MRST Prepared in cooperation with Aeritalia SpA, Turin, Italy and Dornier-Werke GmbH, Friedrichshafen, West Germany
(ETN-88-91074) Avail: NTIS HC A16/MF A01

The Columbus Space Station pressurized module, payload carrier, resource module, and servicing vehicle subsystem requirements are outlined. The structural, thermal control, life support and environmental, and mechanisms and robotics subsystems are discussed. ESA

N88-16801# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).
COLUMBUS FEASIBILITY STUDIES. VOLUME 3: AVIONICS, SYSTEMS Final Report
1986 453 p Sponsored by Bundesministerium fuer Forschung und Technologie/DFVLR and the PCN/MRST Prepared in cooperation with Aeritalia SpA, Turin, Italy and Dornier-Werke GmbH, Friedrichshafen, West Germany
(ETN-88-91075) Avail: NTIS HC A20/MF A01

The Columbus information management, electrical power supply

and distribution, telecommunication, guidance and navigation, attitude control, propulsion; and rendezvous and docking systems are discussed. ESA

N88-16802# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).
COLUMBUS FEASIBILITY STUDIES. VOLUME 5: PROGRAMMATICS Final Report
1986 154 p Sponsored by Bundesministerium fuer Forschung und Technologie/DFVLR and the PCN/MRST Prepared in cooperation with Aeritalia SpA, Turin, Italy and Dornier-Werke GmbH, Friedrichshafen, West Germany
(ETN-88-91076) Avail: NTIS HC A08/MF A01

The Columbus Space Station program planning and cost estimates, development plan/philosophy, and specifications are discussed. ESA

N88-17689# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).
STUDY ON LONG TERM EVOLUTION TOWARDS EUROPEAN MANNED SPACE FLIGHT. VOLUME 1: EXECUTIVE SUMMARY Final Report
UWE RIEDEL, F. STEINSIEK, H.-H. STOLTE, E. SOEFFKER, K.-P. LUDWIG, and J. EWALD, ed. Paris, France ESA Apr. 1987 100 p Prepared in cooperation with Aeritalia SpA, Turin, Italy, Battelle Inst., BAE, Stevenage, England, Dornier-Werke GmbH, Friedrichshafen, West Germany, KAMPSAX ltd., Matra Espace, Toulouse, France, National Aerospace Lab., Amsterdam, Netherlands, et al
(Contract ESA-6669/86-NL-PP(SC))
(MBB-RA3-004/87-VOL-1; ESA-CR(P)-2491-VOL-1; ETN-88-91702-VOL-1) Avail: NTIS HC A05/MF A01

The feasibility of a long-term evolution based on the Columbus operational scenario and the inherent growth potential of the Columbus concept are indicated. In the medium-term (up to 2015), the evolution is driven by the goal of permanent presence of men in space, accompanied by increasing demands from scientific (and commercial) application which requires both man-supported and automated payload operation capabilities, (i.e., evolution towards minimum capability to achieve European autonomy in manned space flight). In the long-term (beyond 2015), requests for operational support capabilities become increasingly dominant for assembly, service, maintenance functions to support GEO, Moon, Mars, and interplanetery missions and to serve as a nodal point for space transportation systems, (i.e., evolution towards full European space station capabilities). ESA

N88-18182*# National Aeronautics and Space Administration, Washington, D.C.
BASIC RESULTS OF MEDICAL STUDIES DURING PROLONGED MANNED FLIGHTS ON-BOARD THE SALYUT-7/SOYUZ-T ORBITAL COMPLEX
Mar. 1988 64 p Transl. into ENGLISH of conference paper presented at the 1st Joint Soviet-American Working Group on Space Biology and Medicine, 1987 Meeting held in Nalchik, USSR, 2-11 Aug. 1987 Transl. by Scientific Translation Service, Santa Barbara, Calif.
(Contract NASW-4307)
(NASA-TT-20217; NAS 1.77:20217) Avail: NTIS HC A04/MF A01 CSCL 06S

From 1982 through 1986 six extended flights (from 65 to 237 days) were carried out in the Salyut-7/Soyuz-T orbital complex by the principal crews, and five short-term flights (8 to 12 days) by visiting crews. During these flights, a broad series of medical studies was performed, their greatest extent during the longest flight (237 days), with the participation of a cosmonaut-doctor. The medical studies were aimed at obtaining additional information and new data on the reactions of the body's basic systems during a prolonged state of weightlessness. Author

N88-18614# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).
COLUMBUS FEASIBILITY STUDIES. VOLUME 4: INTEGRATION, TEST, AND OPERATIONS Final Report
Bonn, West Germany Bundesministerium fuer Forschung und Technologie 1986 379 p Sponsored by Bundesministerium fuer Forschung und Technologie
(ETN-88-90576) Avail: NTIS HC A17/MF A01

A manufacturing, integration, and test plan for the Columbus space station subsystems is outlined. An operations scenario which identifies typical activities on ground and in orbit is presented. ESA

N88-18951*# National Space Development Agency, Tokyo (Japan). Structural Test Dept.
NASDA'S NEW TEST FACILITIES FOR SATELLITES AND ROCKETS
MITSUHIRO TSUCHIYA *In* NASA. Marshall Space Flight Center, The 58th Shock and Vibration Symposium, Volume 2 p 79-90 Feb. 1988
Avail: NTIS HC A10/MF A01 CSCL 09B

The National Space Development Agency of Japan (NASDA) has decided to construct integrated environmental and structural test facilities for large space satellites. These facilities are under construction. The new test facilities are described and some technical considerations, especially for the unique vibration test facility are discussed. Author

N88-19492# MATRA Espace, Toulouse (France).
ASSEMBLY AND SERVICING OF A EUROPEAN SPACE STATION
C. COUGNET *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 53-62 Nov. 1987
Avail: NTIS HC A21/MF A01

The implementation of a European manned space infrastructure as a follow-on to Columbus is discussed. The types of in orbit operations and the elements (vehicles, or other) required by the assembly and servicing of this Space Station are reviewed. Scenarios of construction are discussed with emphasis on the assembly of each Space Station element. The concept of a vehicle necessary for the transportation and assembly of the elements is featured. Analysis of the servicing scenarios highlights the types of servicing vehicle (Hermes, or logistics vehicle using an Ariane extended stage) maintenance operations, and manipulator systems. ESA

N88-19500# MATRA Espace, Toulouse (France).
UTILIZATION OF SMS AND EVA FOR THE SERVICING OF EUROPEAN SPACE STATION
C. COUGNET and T. BLAIS *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 127-137 Nov. 1987
Avail: NTIS HC A21/MF A01

It is shown how the service manipulator system (SMS) and extravehicular activity (EVA) can be used to perform servicing of a space station to succeed Columbus. Most of the external servicing tasks to be done on the Space Station consist of exchanging an orbital replacement unit; the others are related to refuelling, inspection, or repair. The alternative modes to perform these tasks and the problem of unloading the logistics vehicle are discussed. Alternative servicing modes: use of SMS alone, or astronaut in EVA supported by SMS are compared, and typical operation sequence, and modes of control command are reviewed. ESA

N88-19515# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany).
EPOS: EUROPEAN PROXIMITY OPERATIONS SIMULATION
G. HEIMBOLD, J. J. M. PRINS, and W. FEHSE (European Space Agency, European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 273-279 Nov. 1987
Avail: NTIS HC A21/MF A01

A test bed for simulation of rendezvous and docking (RVD) of spacecraft and related to robotics, telemanipulation and servicing in space including berthing operations is described. The test bed provides nine mechanical degrees of freedom and is primarily designed to enable computer controlled simulations in real time and real size. In the case of RVD scaled simulations are envisaged. ESA

N88-19517# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
EUROSIM: A DESIGN CONCEPT FOR AN IN-ORBIT OPERATIONS SIMULATOR
A. ELFVING and J. HOOGSTRATEN (Fokker B.V., Amsterdam, Netherlands) *In its* Proceedings of the 1st European In-Orbit Operations Technology Symposium p 289-297 Nov. 1987
Avail: NTIS HC A21/MF A01

A computer system to simulate space operations of systems such as Columbus and Hermes was designed. The so-called European Robotic Operations Simulator (EUROSIM) is a long life-time simulator for design, verification, test, and training applicable to general in-orbit servicing operations although tailored towards space robotic and manipulator operations. The EUROSIM possibilities include static visualization of orbit characteristics, reference frames, and local geometries; representation of dominating environmental conditions; kinematic and dynamic analysis of generic space elements models; and development of simulation modules in a software development environment. The basic simulation process is a run-time module prepared off-line with the help of extensive user support facilities. Requirements imposed on user-support facilities include an intelligent simulation model editor which allows the dynamic and geometric model of a real world or hypothetical system to be built up from a library of modules, each representing a physical subsystem, component or unit. ESA

N88-19522# Erno Raumfahrttechnik G.m.b.H., Bremen (West Germany).
COLUMBUS SIMULATION FACILITY (CSF)
H.-J. BOECK and E. SCHAFHAUSER *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 335-341 Nov. 1987
Avail: NTIS HC A21/MF A01

A facility to provide software-based simulation of Columbus flight configurations was developed. It features real-time capability and flight modularity/fidelity to satisfy the wide scope of user requirements through all program phases. Staggered implementation with early simulation through all design levels ensures an optimum feedforward/feedback to the design process, reducing the risk and cost for late changes. User friendliness through a broad spectrum of simulation tasks is a governing design goal. Without compromising user aspects, low risk techniques/technology with growth potential are employed. An import/export concept with central management, development, and services ensures a consistent quality of simulation and cost effective development/utilization. ESA

N88-19532# National Aerospace Lab., Amsterdam (Netherlands).
DEFINITION OF THE EUROSIM SIMULATION SUBSYSTEM
C. N. A. PRONK, E. ERSUE, A. L. LIPPAY, and A. ELFVING (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 421-429 Nov. 1987
Avail: NTIS HC A21/MF A01

Requirements for the simulation software of the European Robotics Operations Simulator (EUROSIM) are discussed. A detailed complete specification of the simulation software is not possible due to the wide scope of EUROSIM. Therefore, detailed specifications were given for the kernel model software, i.e., the manipulator models, and high level descriptions for the related models and the simulation definition and control support software. From the study results it should be possible to define a conceptual design of the system/software architecture. With that design and the baseline requirements detailed software requirements can be specified. The various software elements, identified to be part of the simulation subsystem, were specified and development and cost estimates were given in order to arrive at the basic non real-time and real-time operational capabilities. ESA

N88-19533# Technische Hochschule, Darmstadt (West Germany). Fachgebiet Regelsysteemtheorie.
A COMPARATIVE SURVEY OF MATHEMATICAL MODELS FOR DYNAMIC SIMULATION OF IN-ORBIT MANIPULATION OPERATIONS
H. BRUHM, E. ERSUE, and ST. WIENAND *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 431-438 Nov. 1987
(Contract ESA-6482/85-NL-AN)
Avail: NTIS HC A21/MF A01

Requirements for the software simulation of manipulator space-operations, and three methods of dynamic simulation are reviewed. The Lagrangian method is best suited for a simulation which is mainly for analyzing the dynamic behavior of the manipulator arm and for controller-design because of its clear formulation. The dynamic influences are computed explicitly, so thay can be isolated or their contribution to the total dynamic forces seen. However, the Lagrangian formulation requires more computational effort than the others. Kane's method is the most effective as to computational effort. However, automatic generation of the simulation equations in an effective way is not possible. Kane's formulation is well suited for real-time simulations where the manipulator-design is already fixed and no additional results (like forces in the bearings) only simulation of motion, is required. For all other applications the Newton-Euler method is best. Its main advantage is that the forces and torques can be computed explicitly at every point on the manipulator. So the interaction with the environment can be simulated very easily. ESA

N88-19894# European Space Agency, Paris (France). Directorate of Earth Observation and Microgravity.
THE EUROPEAN SPACE AGENCY'S ROLE IN LIFE SCIENCES AND RESEARCH IN SPACE
H. OSER *In its* Proceedings of the 3rd European Symposium on Life Sciences Research in Space p 9-12 Dec. 1987
Avail: NTIS HC A15/MF A01

The ESA spaceborne life science program, covering neurophysiology, cardiovascular and metabolic studies, immunology and cell biology, and radiation biophysics and exobiology is introduced. Experiment facilities on Spacelab, Biorack, Anthrorack, EURECA, Biocosmos, and the shuttle-borne sled are described. The role of ESA in selecting and coordinating experiments is explained. ESA

N88-19895# European Space Agency, Paris (France). Directorate of Earth Observation and Microgravity.
LIFE SCIENCES IN THE FRAMEWORK OF THE ESA MICROGRAVITY PROGRAM AND FUTURE FLIGHT OPPORTUNITIES
G. SEIBERT *In its* Proceedings of the 3rd European Symposium on Life Sciences Research in Space p 13-18 Dec. 1987
Avail: NTIS HC A15/MF A01

The history of ESA's life science program is described, and ongoing and future programs, including cooperation with other agencies, are outlined. Microgravity facilities for EURECA are listed, and the effects of delays in the STS program are shown. Life science opportunities offered by the Columbus Space Station are summarized. ESA

N88-19898# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
EXOBIOLOGY AND BOTANY FACILITIES FOR EURECA
M. GARVIN and J. KINGDON *In its* Proceedings of the 3rd

European Symposium on Life Sciences Research in Space p 27-30 Dec. 1987
Avail: NTIS HC A15/MF A01 CSCL 06C

The Exobiological and Radiation Assembly (ERA) is a multi-user life science facility designed to support investigations into the effects of the radiation environment at low Earth orbit upon living organisms. Two classes of investigation are possible with ERA; the first group concerns the effects selected bandwidths of solar radiation, and the second concerns the effects of HZE particles, upon living material. The Botany Facility is proposed as a multiuser refiyable life science facility, to support research into long term response of higher and lower plants to the microgravity and radiation environments encountered at low Earth orbit; under the appropriate circumstances these same facilities may be used to conduct entomological investigations. Both facilities are compatible with EURECA. ESA

N88-19947# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Inst. for Aerospace Medicine.
MICROGRAVITY USER SUPPORT CENTER (MUSC) FOR EURECA, SPACELAB AND COLUMBUS MISSIONS
D. PADEKEN and M. SCHUBER *In* ESA. Proceedings of the 3rd European Symposium on Life Sciences Research in Space p 279-282 Dec. 1987
Avail: NTIS HC A15/MF A01

A ground support facility offering scientific and operational services to spaceborne microgravity research is described. It supports experiments in biology and medicine enabling easy access to space experiments, efficient experiment preparation, and cost reduction. User support comprises preparation of life science experiments from the initial idea to the qualified space experiment, interactive operation and control of experiments during the flight by telescience, and characterization of biological samples, analyses, and data evaluation before, during and after the mission. ESA

N88-23983*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
METHOD OF RADIOGRAPHIC INSPECTION OF WOODEN MEMBERS Patent Application
MAGGIE L. BERRY, inventor (to NASA) and ROBERT L. BERRY, inventor (to NASA) 25 Nov. 1987 11 p
(NASA-CASE-LAR-13724-1; NAS 1.71:LAR-13724-1; US-PATENT-APPL-SN-125678) Avail: NTIS HC A03/MF A01 CSCL 14D

The invention is a method to be used for radiographic inspection of a wooden specimen for internal defects which includes the steps of introducing a radiopaque penetrant into any internal defects in the specimen through surface openings; passing a beam of radiation through a portion of the specimen to be inspected; and making a radiographic film image of the radiation passing through the specimen, with the radiopaque penetrant in the specimen absorbing the radiation passing through it, therby enhancing the resulting image of the internal defects in the specimen. NASA

19

SUPPORT SPACECRAFT

Includes design, analysis, requirements, trade studies and simulations of Space Station support spacecraft including the orbital transfer vehicle (OTV) and the orbital manuvering vehicle (OMV).

A88-15313
ORBIT DESIGN FOR A SPACE AMBULANCE VEHICLE
WALTER C. NELSON IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 29 p.

A number of rendezvous maneuvers between space stations in geocentric orbits at altitudes ranging between 200 km and geosynchronous altitude are examined. Minimum time to complete rendezvous is studied for purposes of expediting crew patient transfer to an orbiting medical base station (MBS) for the stabilization of trauma and definitive care. The vehicle to be used for the crew patient transfer to the MBS is the space ambulance vehicle (SAV). The SAV is assumed to use two velocity impulses to complete rendezvous maneuvers between an SS and the MBS: an accelerating impulse when departing the SS and a second decelerating impulse prior to docking with the MBS. Recommendations are made concerning the planning of space operations which will reduce both time and propulsive energy for rendezvous maneuvers. It is suggested that throttleable engines be used when transferring a crew patient whose trauma could be exacerbated by excessive acceleration of the carrier vehicle. B.J.

A88-15931*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
ORBITAL MANEUVERING VEHICLE - NEW CAPABILITY
WILLIAM G. HUBER (NASA, Marshall Space Flight Center, Huntsville, AL) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 12 p.
(IAF PAPER 87-194)

The Orbital Maneuvering Vehicle (OMV) program is reviewed with reference to the current status of the program, vehicle description, and mission capabilities. The OMV, which will be available in 1991, will be able to economically deliver and retreive spacecraft from orbits beyond the practical limits of the Shuttle. It will be capable of meeting the present needs of the Space Transportation System and its payloads and the future space activities associated with the Space Station. In addition to the inherent capability of the OMV, it can be enhanced by the addition of special purpose mission kits to meet special mission needs, such as servicing, refueling, and recovery of tumbling satellites. V.L.

A88-15933#
THE SPACE BASED OTV AND THE ESTABLISHMENT OF THE NEXT LAUNCH SITE
PAUL BIALLA and MARK HENLEY (General Dynamics Corp., Space Systems Div., San Diego, CA) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 9 p. refs
(IAF PAPER 87-196)

The Orbital Transfer Vehicle and its in-space support facility are discussed. An overview is given of the orbital transfer infrastructure, and the main design considerations of the OTV are listed and briefly discussed. The Orbital Transfer and Staging Facility is described, including its facility requirements and interfaces. The relevant technology development requirements are addressed, discussing the implementation plan and the usefulness of COLDSAT, a free-flying experiment planned by NASA for launch on an expendable launch vehicle. C.D.

A88-15976#
ORBITAL MANEUVERING VEHICLE (OMV) PROPULSION SUBSYSTEM
SIDNEY ZAFRAN, NEIL F. DIPPREY, and ROBERT L. SACKHEIM (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 10 p.
(IAF PAPER 87-261)

The principal requirement specifications and the general design of the OMV propulsion subsystem currently being developed are described. Key development and qualification tasks involve the variable thrust engines, the 12-lbf regulated hydrazine thruster; propellant and pressurized tanks; and the hydrazine fluid couplings. The design of the system allows for multiple missions, with maintenance, over a lifetime of 10 years. A trade tree and selection criteria of the propulsion subsystem are shown. V.L.

A88-22217#
AEROASSISTED ORBITAL TRANSFER VEHICLE GUIDANCE PERFORMANCE IN THE PRESENCE OF DENSITY DISPERSIONS
STEVE M. FITZGERALD and DONALD T. WARD (Texas A & M University, College Station) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(AIAA PAPER 88-0302)

The performance sensitivity of two aeroassisted orbit transfer vehicle concepts for atmospheric guidance of geosynchronous orbit return trajectories to atmospheric density variations is simulated. The resulting atmospheric exit states are normalized by values from a 1962 standard density profile simulation, for both the analytic predictor-corrector and energy controller algorithms. The longitudinal targeting capabilities of the guidance schemes show strong sensitivity to the location and the magnitude of the dispersions. Lateral guidance performance of the energy controller is more sensitive to the dispersion parameters; in general, this alternative is the most sensitive to density variations. O.C.

A88-26364#
SMALL REENTRY VEHICLES [KLEINE RE-ENTRY VOERTUIGEN]
K. J. SUDMEIJER (Fokker, Schiphol, Netherlands) Ruimtevaart, vol. 36, Dec. 1987, p. 15-26. In Dutch.

The design and potential applications of a small modular unguided reentry vehicle (SMURV) being developed for ESA are discussed. The first studies of the SMURV concept in the Spacemail program (for transporting small payloads from the Space Shuttle to earth) are recalled; the steps in a typical Spacemail operation are listed and briefly characterized; and the smaller version of SMURV (40 kg instead of 120 kg) developed for a Space Station Spacemail project (requiring 1000-1500 SMURVs) is described. This SMURV configuration comprises a detachable propulsion module and a reentry module (containing the parachute system and the recovery module). Consideration is given to a SMURV-type vehicle to return microgravity processing samples from the ESA Interim Flight Opportunity spacecraft, the technological challenges posed by SMURV design, and SMURV applications to the Comet Nucleus Sample Return and Cassini Titan Lander missions. Diagrams and drawings are provided. T.K.

A88-27887#
HIGH-ENERGY ORBIT REFUELING FOR ORBITAL TRANSFER VEHICLES
BRUCE P. DUNN (British Columbia, University, Vancouver, Canada) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, Nov.-Dec. 1987, p. 518-522. refs

The payload capabilities and fuel economy of chemically powered orbital transfer vehicles are severely limited by the specific impulse of the available chemical propellants. Midmission refueling of payload-carrying chemically powered orbital transfer vehicles using propellant lifted into high-energy orbits by high-specific-impulse electrically powered orbital transfer vehicles results in substantially higher payloads for a given size of chemical vehicle and in overall propellant savings. For the transport of payloads to geosynchronous orbit, circular and elliptical refueling orbits intermediate between low earth and geosynchronous orbits each have specific advantages. High-energy-orbit refueling is also advantageous for earth escape missions and for utilization of lunar-derived propellants. Author

N88-14116*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AN ANALYSIS OF THE EFFECT OF AEROASSIST MANEUVERS ON ORBITAL TRANSFER VEHICLE PERFORMANCE
GREGORY O. MURPHY and WILLIAM T. SUIT Sep. 1987 21 p
(NASA-TM-89117; NAS 1.15:89117) Avail: NTIS HC A03/MF A01 CSCL 22B

This paper summarizes a Langley Research Summer Scholars (LARSS) research project (Summer 1986) dealing with the topic of the effectiveness of aeroassist maneuvers to accomplish a change in the orbital inclination of an Orbital Transfer Vehicle (OTV). This task was subject to OTV design constraints, chief of which were the axial acceleration and the aerodynamic heating rate limits of the OTV. The use of vehicle thrust to replace lost kinetic energy and, thereby, to increase the maximum possible change in orbital inclination was investigated. A relation between time in the hover orbit and payload to LEO was established. The amount of plane change possible during this type of maneuver was checked for several runs and a possible thrusting procedure to increase the plane change and still get to LEO was suggested. Finally, the sensitivity of various target parameters to controllable independent variables was established, trades between the amount of control allowed, and payload to LEO suggested. Author

N88-15831*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
ORBITAL TRANSFER VEHICLE STUDIES OVERVIEW
DON PERKINSON *In* NASA. Lewis Research Center, Cleveland, Ohio. Cryogenic Fluid Management Technology Workshop. Volume 1: Presentation Material and Discussion p 139-150 Sep. 1987
Avail: NTIS HC A17/MF A01 CSCL 22B

An overview is given in viewgraph form of orbital transfer vehicle concept definition and systems analysis studies. Project development flow charts are shown for key milestones from 1985 until 1997. Diagrams of vehicles are given. Information is presented in outline form on technology requirements, cooling of propellant tanks, cryogenic fluid management, quick connect/disconnect fluid interfaces and propellant mass transfer. R.J.F.

N88-18609*# Martin Marietta Corp., Denver, Colo.
ORBITER TRANSFER VEHICLE CONCEPT DEFINITION AND SYSTEM ANALYSIS STUDY. VOLUME 4: SPACE STATION ACCOMMODATIONS. REVISION 1 Final Report, Jul. 1984 - Oct. 1985
ROGER M. RANDALL Jul. 1987 436 p
(Contract NAS8-36108)
(NASA-CR-179293; NAS 1.26:179293; MCR-86-2601-VOL-4-REV-1) Avail: NTIS HC A19/MF A01 CSCL 22B

A brief summary is given of the key objectives of Task 5 of the Space Station Accommodations Concept Definition. Space station accommodations were assessed and defined for each potential candidate Space-Based OTV concept and for the composite OTV fleet. To accomplish this, the functional and physical interactions between each OTV concept and the space station were defined. Then, conceptual accommodation designs were prepared and optimized for approach and configuration. Initial space station requirements were identified, including the ability to accommodate and support evolution to maturity, and then a time-phasing of accommodations was prepared showing that evolution. In the process of developing physical and functional interactions, operational requirements were defined, together with associated timelines. In that the crew complement is subject to limitations, the operational requirements derivation is biased toward automation wherever possible. For each candidate Ground-Based OTV concept, operating in conjunction with the space station, the above process was repeated. Author

N88-18610*# Martin Marietta Corp., Denver, Colo.
ORBITAL TRANSFER VEHICLE CONCEPT DEFINITION AND SYSTEM ANALYSIS STUDY. VOLUME 4, APPENDIX A: SPACE STATION ACCOMMODATIONS. REVISION 1 Final Report, Jul. 1984 - Oct. 1985
ROGER M. RANDALL Jul. 1987 305 p
(Contract NAS8-36108)
(NASA-CR-179294; NAS 1.26:179294; MCR-86-2601-VOL-4-APP-A-REV-1) Avail: NTIS HC A14/MF A01 CSCL 22B

Orbit Transfer Vehicle (OTV) processing at the space station is divided into two major categories: OTV processing and assembly operations, and support operations. These categories are further subdivided into major functional areas to allow development of

detailed OTV processing procedures and timelines. These procedures and timelines are used to derive the specific space station accommodations necessary to support OTV activities. The overall objective is to limit impact on OTV processing requirements on space station operations, involvement of crew, and associated crew training and skill requirements. The operational concept maximizes use of automated and robotic systems to perform all required OTV servicing and maintenance tasks. Only potentially critical activities would require direct crew involvement or supervision. EVA operations are considered to be strictly contingency back-up to failure of the automated and robotic systems, with the exception of the initial assembly of Space-Based OTV accommodations at the space station, which will require manned involvement. Author

N88-19486# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Space Operations Center.
SAFE RENDEZVOUS APPROACH TO A SPACE STATION BY IMPULSIVE TRANSFERS AND CONTINUOUS THRUST ARCS
MARTIN C. ECKSTEIN *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 3-12 Nov. 1987
Avail: NTIS HC A21/MF A01

The Clohessy-Wiltshire equations are used to design approach trajectories towards an orbiting space station with the emphasis on safety aspects, particularly the avoidance of any collision hazard. The trajectories are designed such that any interruption of maneuver sequence, maneuver failures, or underburns does not result in a collision course. Orbit control is approximated by impulsive transfers and continuous thrust arcs. Dispersions due to orbit determination and maneuver, and maneuver errors are considered. The results are verified by simulations of the approach trajectories. ESA

N88-19499*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
IN-ORBIT AND LABORATORY EXCHANGE OF ORUS DESIGNED/NOT DESIGNED FOR SERVICING
R. DAVIS *In* ESA. Proceedings of the 1st European In-Orbit Operations Technology Symposium p 123-126 Nov. 1987
Avail: NTIS HC A21/MF A01 CSCL 22B

The practicality of employing a combination of automated and extravehicular activity forms of servicing in-orbit was demonstrated with the STS 41-C Solar Maximum Repair Mission. This shows that modular Orbital Replacement Units (ORUs) designed for servicing can be readily accommodated. Successful replacement of an experiment ORU, not designed for replacement, was performed following extensive preparations. In a laboratory, spacecraft ORUs were replaced using a completely preplanned automated approach. This was later done using a completely unstructured teleoperations mode including the complicated exchange of the instrument ORU. As a result of this effort and work on powered tools, an approach for combining these techniques is underway to produce a flight support system servicing aid to increase the STS astronauts' effective in-orbit servicing capability by several fold. ESA

N88-20005*# Alabama Univ., Huntsville. Dept. of Psychology.
OMV MAN/SYSTEM SIMULATION INTEGRATION: A PRELIMINARY ANALYSIS AND RECOMMENDATION Final Report
JON G. ROGERS 11 Apr. 1988 50 p
(Contract NAG8-546)
(NASA-CR-182602; NAS 1.26:182602) Avail: NTIS HC A03/MF A01 CSCL 05H

The Orbital Maneuvering Vehicle (OMV) presents a series of challenges to the human operator. Some are unique to the OMV system itself, and are largely due to remote control versus control from the cockpit. Other challenges are not necessarily unique to the OMV, but are characteristic of many man-machine space flight systems. All of these challenges affect the operator's ability to perform his portion of the mission, and could lead to human error which might jeopardize the vehicle, mission, or both. It is imperative to make every effort to design the control and displays to facilitate the operator's task. The experimental program should address the perceptual, mediational, and motor dimensions of operator performance. With this in mind, a literature review with relevant design considerations was initiated, and a comprehensive outline of control/display parameters were developed. Out of this, a series of questions not answered in the literature was derived which can be converted into experimental protocols for the simulation program. A major task of the aircraft pilot as well as the OMV operator is prediction. Certain display principles have proved to enhance the pilot's ability to predict. A brief examination of some of these principles in relationship to OMV may be useful. B.G.

20

LIFE SCIENCES/HUMAN FACTORS/SAFETY

Includes studies, models, planning, analyses and simulations for biological and medical laboratories, habitability issues for the performance and well-being of the crew, and crew rescue.

A88-10947*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
CREW FACTORS IN THE DESIGN OF THE SPACE STATION
JUDITH L. ROBINSON (NASA, Johnson Space Center, Houston, TX) Princeton University and AIAA, Conference on Space Manufacturing, 8th, Princeton University, NJ, May 6-9, 1987, Paper. 10 p.

The designing of Space Shuttle modules and equipment in order to provide a stimulating and efficient work atmosphere and a pleasant living environment is examined. The habitation module for the eight crew members is divided into four areas: ceiling, floor, port, and starboard. The module is to consist of crew quarters, a wardroom, a galley, a personal hygiene facility, a health maintenance facility, and stowage areas. There is a correlation between the function of the module and its location; for example the galley will be near the wardroom and the personal hygiene facility near the crew quarters. The designs of the equipment for crew accommodation and of the equipment to be maintained and repaired by the crew will be standarized. The design and functions of the crew and equipment restraints, crew mobility aids, racks to contain equipment, and functional units are described. I.F.

A88-15283
TECHNOLOGY ADVANCEMENTS TO IMPROVE CREW PRODUCTIVITY IN SPACE
MELANIE M. MANKAMYER (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 7 p.

Advances in technologies that will improve crew productivity and comfort on the Space Station are reviewed. These technologies include the development of computer tools to optimize the crew work place in the Space Station (e.g., solid modeling and interior layout evaluation programs) as well as advances in Station equipment to minimize or eliminate tedious and/or time-intensive tasks. These latter advances include automated inventory management and equipment controls, galley oven, housekeeping and trash compactor technologies, and personal hygiene improvements in the waste management system and full body shower. A third area of advancement is the development of job aids and procedural improvements for the everyday operation and maintenance of Station equipment and experiments. These advances include EVA space suit and glove design and procedural aids such as an operations and maintenance information system. B.J.

A88-15348
SMALL GROUPS IN ORBIT - GROUP INTERACTION AND CREW PERFORMANCE ON SPACE STATION

JOHN M. NICHOLAS (Loyola University, Chicago, IL) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 58, Oct. 1987, p. 1009-1013. Research supported by the James A. Kemper Foundation. refs

Orbiting space stations raise unprecendenied demands on crew performance and group interaction. Previously, Antarctic studies revealed evidence of deterioration in social relationships and work effectiveness, particularly during the long winter; a decline was observed in compatibility, group pride, teamwork, and group efficiency, and groups with the greatest decline had the lowest morale and experienced most difficulty in keeping essential equipment operating. These findings are consistent with reports from Soviet Salyut missions. It is noted that, in spite of these reports, the interpersonal criterion is virtually ignored in the current Space Station planning. Directions for possible training and team development are suggested. I.S.

A88-15830#
EUROPEAN EVA REQUIREMENTS AND SPACE SUIT DESIGN
L. LEMAIGNEN, M. WEIBEL (Avions Marcel Dassault Breguet Aviation, Saint-Cloud, France), and J. HEYN (Dornier System GmbH, Friedrichshafen, Federal Republic of Germany) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 11 p. refs
(IAF PAPER 87-41)

EVA activities associated with operations of the Columbus space station and the Hermes manned reusable spacecraft require space suits for ESA astronauts characterized by high mobility and dexterity, exceptional protection against radiation, thermal loads, and micrometeoroids, and good communications equipment. Such suits must also minimize donning/doffing time and prebreathing requirements. Attention is presently given to operational performance criteria that must be met by these suits in the course of EVA concerned with Orbit Replaceable Units on such ESA spacecraft as the enhanced Eureca platform, as well as to the anthropometric constraints of suit geometry. O.C.

A88-16151#
COSMONAUT BEHAVIOUR IN ORBITAL FLIGHT SITUATION - PRELIMINARY ETHOLOGICAL ANALYSIS
C. TAFFORIN, B. THON, R. CAMPAN (Toulouse III, Universite, France), and A. GUELL (CNES, Groupe Biologique et Medical Spatial, Toulouse, France) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 10 p. refs
(IAF PAPER 87-528)

A frame by frame analysis of current video-tape recordings reveals that the behavioral adaptation process of the cosmonaut to weightlessness is achieved via adaptation of the motor units patterns according to the movement direction, differential responses in the movement kinetics according to the attention level of the cosmonaut while performing the task, and to the needed accuracy. Results are presented pertaining to the cosmonaut's posture and body orientation. It is found that the cosmonaut systematically orientates according to visual references of his proximate spatial environment. K.K.

A88-16159#
BIOMEDICAL PAYLOAD OF THE FRENCH-SOVIET LONG DURATION FLIGHT
L. BRAAK, J. THOULOUSE, A. CHAPPE, D. VASSAUX (CNES, Toulouse, France), A. I. GRIGOR'EV (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) et al. IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 4 p.
(IAF PAPER 87-541)

The French-Soviet long-duration flight, planned for the second half of 1988, is expected to have a duration of 30 days. The mission payload will include the study of the cardiovascular system, the study of sensori-motor interactions, and radioprotection. Hemodynamic data will be collected using a new version of Echograph which makes it possible to obtain imagery of all organs and blood vessels accessible to clinical echography. The Physalie experiment will permit a better understanding of the effects of lack of gravity on the components of the central nervous system and their interaction both in the fast and longer term phases of adaptation. K.K.

A88-16162#
SUPPORT OF LIFE SCIENCE RESEARCH IN SPACE BY THE DFVLR MICROGRAVITY USER SUPPORT CENTER (MUSC)
D. PADEKEN, M. SCHUSER, C. LINDBERG, G. REITZ, H. BUECKER (DFVLR, Institut fuer Flugmedizin, Cologne, Federal Republic of Germany) et al. IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 4 p.
(IAF PAPER 87-544)

The activities being undertaken by DFVLR-MUSC to facilitate the planning and execution of space biomedical research are reviewed and illustrated with diagrams, drawings, and tables. Consideration is given to the experiments planned for the Exobiology and Radiation Assembly of Eureca-1; ground simulation of Anthrorack physiology experiments for the second FRG Spacelab mission (D-2); and the Ariadne information system for the acquisition, processing, and dissemination of experimental data. T.K.

A88-16163#
PROVIDING ARTIFICIAL GRAVITY - PHYSIOLOGIC LIMITATIONS TO ROTATING HABITATS
PETER H. DIAMANDIS IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 19 p. refs
(IAF PAPER 87-545)

The medical rationale for artificial gravity is examined and past investigations of optimal rotation velocity and habitat radius are reviewed. The artificial gravity sleeper, a proposed countermeasure for long duration space flight, is also discussed. The physiologic changes and potential concerns due to long duration habitation in zero gravity are discussed with emphasis placed on the renal/fluid shift, cardiovascular deconditioning, osteoporosis, immune system changes, and reproductive capability. K.K.

A88-16167#
NASA-STD-3000, MAN-SYSTEM INTEGRATION STANDARDS - THE NEW SPACE HUMAN ENGINEERING STANDARDS
KEITH H. MILLER and CHARLES W. GEER (Boeing Aerospace Co., Seattle, WA) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 8 p.
(IAF PAPER 87-550)

Various aspects of the process used to develop NASA-STD-3000, Man-System Integration Standards (MSIS) are reviewed, as are the documents, the database, and a videotape that are currently available from NASA. The MSIS provides the specific information needed to ensure proper integration of the man-system interface requirements with those of other aerospace disciplines. In addition to the requirements, the MSIS provides design considerations and examples which help the user understand the rationale behind the requirements. The implementation and maintenance of MSIS are also discussed. V.L.

A88-16170#
LOW-COST PROTOTYPES FOR HUMAN FACTORS EVALUATION OF SPACE STATION CREW EQUIPMENT
DAVID NIXON, CHRIS MILLER, JOE KENNEDY, BRAD SKEPNER (Space Projects Group, Santa Monica, CA), and TOM TAYLOR (Spacehab, Inc., Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 9 p. refs
(IAF PAPER 87-553)

The development of inexpensive prototypes for human factor evaluation of Space Station crew equipment is demonstrated with several examples. These include testing of a multipurpose wardroom table, intended for crew meetings, meals, and work applications; portable/wearable workstation, which will provide Space Station crew members with a compact, portable, and versatile facility with communications, data, and audio-visual management and interface capabilities; and passive leg restraint.

Consideration is also given to the prototype fabrication/flight-test costs. I.S.

A88-16182#
SPACE BIOLOGIST'S INFLIGHT SAFETY CONSIDERATIONS
A. COGOLI (Zuerich, Eidgenoessische Technische Hochschule, Zurich, Switzerland) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 4 p.
(IAF PAPER 87-570)

Safety constraints arising in the preparation of biological experiments for manned space laboratories are related to instrumentation, and to biological, chemical, and radioactive hazards. A more standardized application of safety rules by different space centers is suggested as well as an improved understanding between investigators and safety engineers. In addition, The Space Station/Columbus Utilization Preparation Program encourages the use of off-the-shelf hardware on future Spacelab missions. K.K.

A88-16187#
CREWMAN RESCUE EQUIPMENT IN MANNED SPACE MISSIONS - ASPECTS OF APPLICATION
G. I. SEVERIN, I. P. ABRAMOV, and V. I. SVERTSHEK (AN SSSR, Sovet Interkosmos, Moscow, USSR) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 6 p. refs
(IAF PAPER 87-576)

The application of survival suits to earth-to-orbit transport vehicles, permanently orbiting space stations, and interplanetary spacecraft is discussed. Crewman activities during various emergencies are described along with the role of the suit. The features of different types of survival suits are examined. C.D.

A88-20282* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE OPPORTUNITIES FOR SPACE BIOLOGY RESEARCH ON THE SPACE STATION
RODNEY W. BALLARD and KENNETH A. SOUZA (NASA, Ames Research Center, Moffett Field, CA) IN: Biological Sciences in Space 1986. Tokyo, MYU Research, 1987, p. 247-252. refs

The life sciences research facilities for the Space Station are being designed to accommodate both animal and plant specimens for long durations studies. This will enable research on how living systems adapt to microgravity, how gravity has shaped and affected life on earth, and further the understanding of basic biological phenomena. This would include multigeneration experiments on the effects of microgravity on the reproduction, development, growth, physiology, behavior, and aging of organisms. To achieve these research goals, a modular habitat system and on-board variable gravity centrifuges, capable of holding various animal, plant, cells and tissues, is proposed for the science laboratory. Author

A88-20864* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
PSYCHIATRIC COMPONENTS OF A HEALTH MAINTENANCE FACILITY (HMF) ON SPACE STATION
PATRICIA A. SANTY (NASA, Johnson Space Center; Flight Medicine Clinic, Houston, TX) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 58, Dec. 1987, p. 1219-1224. refs

The operational psychiatric requirements for a comprehensive Health Maintenance Facility (HMF) on a permanently manned Space Station are examined. Consideration is given to the psychological health maintenance program designed for the diagnosis of mental distress in astronauts during flight and for prevention of mental breakdown. The types of mental disorders that can possibly affect the astronauts in flight are discussed, including various organic, psychotic, and affective mental disorders, as well as anxiety, adjustment, and somatoform/dissociative disorders. Special attention is given to therapeutic considerations for psychiatric operations on Space Station, such as restraints, psychopharmacology, psychotherapy, and psychosocial support. I.S.

A88-21109
A SMOKE REMOVAL UNIT
P. J. BIRBARA (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) and J. T. LEONARD (U.S. Navy, Naval Research Laboratory, Washington, DC) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 9 p.
(SAE PAPER 871449)

A smoke removal unit (SRU) for the clearing and maintenance of atmospheres in spacecraft cabins, ships, and submarine compartments after a fire has been the object of a development effort encompassing both a test phase, conducted under controlled and instrumented laboratory fire conditions, and a design phase which incorporated the knowledge thus gained. The concept of standardized smoke and toxic gas filters is found to be an effective means for the achievement of postfire clearing of closed environments under a variety of fire conditions; a self-contained, semiportable SRU of this type has been designed. O.C.

A88-21116
BIOISOLATION ON THE SPACE STATION - OF MICE AND MEN
PAUL DOLKAS and TERI SCHNEPP (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 9 p.
(SAE PAPER 871457)

The results of three months of testing using rodents in a breadboard biological isolator cage are presented. These cages are designed to provide isolation using microbial air filters on both inlet and outlet. Four different types of filters were tested: a conventional HEPA filter (rated 99.97-percent efficient at 0.3 microns), a 'hospital' grade HEPA filter (95-percent efficient at 0.3 microns), and two grades of 'Filtrete' - a proprietary 3 M polypropylene material (rated 84-percent and 97.3-percent, respectively, at 0.3 microns). Test results showed excellent performance on all filters, meeting or exceeding the strict particulate and microbial air quality standards proposed for the outlet of the animal holding facility: class 100 and 10 Colony Forming Units/cu m. In addition, it was discovered that the fiberglass batting used inside the cage to contain animal waste served as an effective microbial filter by itself. Author

A88-21122* Management and Technical Services Co., Houston, Tex.
LIFE SCIENCES BIOMEDICAL RESEARCH PLANNING FOR SPACE STATION
GARY R. PRIMEAUX (RCA Government Services; Management and Technical Services Co., Houston, TX), ROGER MICHAUD, LADONNA MILLER, JIM SEARCY, and BERNISTINE DICKEY (NASA, Johnson Space Center, Houston, TX) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 9 p. refs
(SAE PAPER 871464)

The Biomedical Research Project (BmRP), a major component of the NASA Life Sciences Space Station Program, incorporates a laboratory for the study of the effects of microgravity on the human body, and the development of techniques capable of modifying or counteracting these effects. Attention is presently given to a representative scenario of BmRP investigations and associated engineering analyses, together with an account of the evolutionary process by which the scenarios and the Space Station design requirements they entail are identified. Attention is given to a tether-implemented 'variable gravity centrifuge'. O.C.

A88-21123
BONES AND STONES IN SPACE - INTEGRATING THE MEDICAL AND SCIENTIFIC QUESTIONS
CHRISTOPHER E. CANN (California, University, San Francisco) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 9 p. refs
(SAE PAPER 871465)

Bone loss and muscle atrophy are two consequences of long-term spaceflight, and neither the underlying mechanisms nor

effective countermeasures have yet been found. Experiments designed for Space Station and beyond incorporate a number of scientific objectives focused on two interrelated concepts, calcium homeostasis and bone homeostasis. The experiments to be done require a trade-off between ground based analysis of samples and development of instruments to do these studies inflight. The scientific community is currently in the process of defining which scientific objectives can be accomplished inflight and what instrumentation is required to do this. Author

A88-21124* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
BIOTECHNOLOGY OPPORTUNITIES ON SPACE STATION
JESS DEMING, KEITH HENDERSON, ROBERT W. PHILLIPS (NASA, Johnson Space Center, Houston, TX), BERNISTINE DICKEY, PHYLLIS GROUNDS (RCA Government Services; Management and Technical Services Co., Houston, TX) et al. SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 7 p.
(SAE PAPER 871468)

Biotechnology applications which could be implemented on the Space Station are examined. The advances possible in biotechnology due to the favorable microgravity environment are discussed. The objectives of the Space Station Life Sciences Program are: (1) the study of human diseases, (2) biopolymer processing, and (3) the development of cryoprocessing and cryopreservation methods. The use of the microgravity environment for crystal growth, cell culturing, and the separation of biological materials is considered. The proposed Space Station research could provide benefits to the fields of medicine, pharmaceuticals, genetics, agriculture, and industrial waste management. I.F.

A88-21130* Sterling Software, Palo Alto, Calif.
AN INNOVATIVE EXERCISE METHOD TO SIMULATE ORBITAL EVA WORK - APPLICATIONS TO PLSS AUTOMATIC CONTROLS
RENEE LANTZ (Sterling Software, Palo Alto, CA), H. VYKUKAL, and BRUCE WEBBON (NASA, Ames Research Center, Moffett Field, CA) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 8 p. refs
(SAE PAPER 871475)

An exercise method has been proposed which may satisfy the current need for a laboratory simulation representative of muscular, cardiovascular, respiratory, and thermoregulatory responses to work during orbital extravehicular activity (EVA). The simulation incorporates arm crank ergometry with a unique body support mechanism that allows all body position stabilization forces to be reacted at the feet. By instituting this exercise method in laboratory experimentation, an advanced portable life support system (PLSS) thermoregulatory control system can be designed to more accurately reflect the specific work requirements of orbital EVA. Author

A88-21144* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
MEDICAL EFFECTS OF IODINE DISINFECTION PRODUCTS IN SPACECRAFT WATER
RICHARD L. SAUER (NASA, Johnson Space Center, Houston, TX), DANIEL S. JANIK (NASA, Johnson Space Center, Houston, TX; National Research Council, Washington, DC; Utah, University, Salt Lake City), and YVONNE R. THORSTENSON (NPI, Salt Lake City, UT) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 14 p. refs
(SAE PAPER 871490)

Various iodination products (IDPs), including iodinated and iodine-induced new compounds, will be present in the iodine-disinfected water that is expected to be used by crews on the NASA Space Station and on long duration missions. The metabolic intermediaries created by such a process may be more important to crew health than the parent IDPs, and reclamation and recycling may be expected to produce additional products. These medical effects may be expressed in crews as hypersensitivity, allergic, acute toxic, and chronic toxic reactions, as well as modifications of immune system response. O.C.

A88-21163
EVOLUTIVE CONCEPT OF AN EVA SPACE SUIT
LOUIS LEMAIGNEN and MARC WEIBEL (Avions Marcel Dassault-Breguet Aviation, Saint-Cloud, France) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 12 p.
(SAE PAPER 871518)

After a short review of the European needs for EVAs (space Extra Vehicular Activities), the paper analyzes the different requirements and constraints of a space station and of a space plane for the EVA aspects. The leading factors which affect the space suit design are presented and analyzed at the light of the evolution of American and Soviet space suits. Among these factors, are: conflict of vehicle and suit pressure choices, protection against radiation, cost of EVA in terms of weight, volume and energy, interfaces with the carrier vehicle, maintainability and vulnerability. From this analysis, two types of suits seem to emerge as optimal solutions. An evolutive approach is proposed in which a common hard upper torso fulfils the requirements of both the space station and the space plane. Modular items are used in accordance with the vehicle to service. The geometrical concept is presented with CAE analysis of the donning procedure. The technology of the major suit components is shortly discussed. Author

A88-21570
SCIENTIFIC OBJECTIVES AND FUNCTIONAL REQUIREMENTS OF LIFE SCIENCES IN THE SPACE STATION
FLEMMING BONDE-PETERSEN (Rigshospitalet, Copenhagen, Denmark) (Columbus II; Proceedings of the Second Workshop, Hanover, Federal Republic of Germany, June 9-11, 1986) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 7, no. 1-2, 1987, p. 157-160.

The types of biomedical experiments planned for the International Space Station are listed and briefly characterized, indicating the operational capabilities and equipment they require. Primary objectives include descriptive and applied human physiology and medicine, animal physiology, plant physiology, cellular physiology, radiation biology and exobiology, and bioprocessing. Consideration is given to the relatively noncritical microgravity specifications for life-science experiments (typically 0.001 g or less), the crew-intervention requirements, the arrangement of experimental equipment in the Pressurized Module, and the integration of a large centrifuge module in the core Space Station. T.K.

A88-22330*# Loyola Univ., Chicago, Ill.
CREW PRODUCTIVITY ISSUES IN LONG-DURATION SPACE FLIGHT
JOHN M. NICHOLAS (Loyola University, Chicago, IL), H. CLAYTON FOUSHEE (NASA, Ames Research Center, Moffett Field, CA), and FRANCIS L. ULSCHAK (H. Lee Moffitt Cancer Research Institute, Tampa, FL) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 13 p. refs
(AIAA PAPER 88-0444)

Considerable evidence suggests the importance of teamwork, coordination, and conflict resolution to the performance and survival of isolated, confined groups in high-technology environments. With the advent of long-duration space flight, group-related issues of crew functioning will take on added significance. This paper discusses the influence of crew roles, status, leadership, and norms on the performance of small, confined groups, and offers guidelines and suggestions regarding organizational design, crew selection, training, and team building for crew productivity and social well-being in long-duration spaceflight. Author

A88-22331#
ONBOARD TRAINING FOR THE SPACE STATION
DONA M. ERB (Mitre Corp., Houston, TX) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p. refs
(AIAA PAPER 88-0445)

For perhaps the first time, training for work in space has been defined as a necessary component of onboard activities. This paper describes the problems which drive the onboard training requirements. Three modes of training are described as solutions to these problems. Examples of potential implementation techniques for the training, using new technologies, are included. The three proposed modes of onboard training are: (1) an off-line capability to be used for computer-assisted instruction and procedural reviews, (2) a job performance assistance mode to provide rapid access to instruction and other forms of on-line help, and (3) a simulation mode for rehearsing robotic and other dynamic system activity. Author

A88-22405*# Wyle Labs., Inc., Huntsville, Ala.
EXPERIMENTS TO ENSURE SPACE STATION FIRE SAFETY - A CHALLENGE
W. W. YOUNGBLOOD and K. M. SEISER (Wyle Laboratories, Inc., Huntsville, AL) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. refs
(Contract NAS3-25067)
(AIAA PAPER 88-0540)

Three experiments have been formulated in order to address prominent fire safety requirements aboard the NASA Space Shuttle; these experiments are to be conducted as part of a Space Station-based Technology Development Mission for the growth phase of Space Station construction and operation. The experiments are: (1) an investigation of the flame-spread rate and combustion-product evolution in the burning of typical spacecraft materials in low gravity; (2) an evaluation of the interaction of fires and candidate fire extinguishers in low gravity; and (3) an investigation of the persistence and propagation of smoldering and deep-seated combustion in low gravity. O.C.

A88-24101
NASA TO EVALUATE TWO SUIT DESIGNS FOR SPACE STATION
CAROLE A. SHIFRIN Aviation Week and Space Technology (ISSN 0005-2175), vol. 129, Jan. 11, 1988, p. 36-39.

Two different space suit configurations are undergoing testing to evaluate usefulness in EVAs associated with the NASA Space Station, which will be of longer duration than heretofore. NASA's Johnson Space Center developed the Zero Prebreathe Suit (ZPS) Mk.3, while NASA Ames developed the AX-5. Both designs use a rear torso hatch for ingress and egress; while the ZPS uses a combination of hard and soft elements, however, the AX-5 is composed entirely of solid, articulated segments. During testing, crew members will engage in assembly and construction tasks simulating the building of the Space Station structures. O.C.

A88-29104
THE ROLE OF PREVENTIVE MEDICINE IN THE FUTURE OF USA SPACE LIFE SCIENCES
JAMES M. VANDERPLOEG (Kelsey-Seybold Clinic, Houston, TX) IN: Biological sciences in space 1986; Proceedings of the 1986 International Symposium, Nagoya, Japan, Nov. 10-12, 1986. Tokyo, MYU Research, 1987, p. 1-8. refs

The preventive, diagnostic, and treatment capabilities of the Health Maintenance Facility (HMF) which will fly aboard the Space Station are discussed. The preventive aspects of the HMF will include facilities for fitness-maintenance exercises and for the periodic collection and evaluation of physiological data which will be used to detect early changes in physiological parameters and to institute corrective measures if needed. This data base will also help to determine the natural history of physiologic changes in space and to define the physiologic norms for microgravity. The dignostic capabilities, which will include cardiorespiratory assessment, clinical laboratory analyses, and imaging system, will enable the crew members to detect and diagnose medical problems inflight and to initiate remedial action immediately. The treatment capabilities will include a life support module, an anesthesia and minor surgery work station, intravenous fluid generation and therapy, a hyperbaric treatment facility, and a pharmacy. I.S.

A88-29134* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE OPPORTUNITIES FOR SPACE BIOLOGY RESEARCH ON THE SPACE STATION
RODNEY W. BALLARD and KENNETH A. SOUZA (NASA, Ames Research Center, Moffett Field, CA) IN: Biological sciences in space 1986; Proceedings of the 1986 International Symposium, Nagoya, Japan, Nov. 10-12, 1986. Tokyo, MYU Research, 1987, p. 247-252. refs

The goals of space biology research to be conducted aboard the Space Station in 1990s include long-term studies of reproduction, development, growth, physiology, behavior, and aging in both animals and plants. They also include studies of the mechanisms by which gravitational stimuli are sensed, processed, and transmitted to a responsive site, and of the effect of microgravity on each component. The Space Station configuration will include a life sciences research facility, where experiment cyles will be on a 90-day basis (since the Space Station missions planned for the 1990s call for 90-day intervals). A modular approach is taken to accomodate animal habitats, plant growth chambers, and other specimen holding facilities; the modular habitats would be transportable between the launch systems, habitat racks, a workbench, and a variable-gravity centrifuge (included for providing artificial gravity and accurately controlled acceleration levels aboard Space Station). I.S.

A88-29140* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NEED, UTILIZATION, AND CONFIGURATION OF A LARGE, MULTI-G CENTRIFUGE ON THE SPACE STATION
SJOERD L. BONTING (NASA, Ames Research Center, Moffett Field, CA) IN: Biological sciences in space 1986; Proceedings of the 1986 International Symposium, Nagoya, Japan, Nov. 10-12, 1986. Tokyo, MYU Research, 1987, p. 297-305. refs

A large, multi-g centrifuge is required on the Space Station (1) to provide valid 1-g controls for the study of zero-g effects on animals and plants and to study readaptation to 1 g; (2) to store animals at 1 g prior to short-term zero-g experimentation; (3) to permit g-level threshold studies of gravity effects. These requirements can be met by a 13-ft-diam., center-mounted centrifuge, on which up to 48 modular habitats with animals (squirrel monkey, rat, mouse) and plants are attached. The advantages of locating this centrifuge with the vivarium, a common environmental control and life support system, a general-purpose work station and storage of food, water, and supplies in an attached short module, are elaborated. Servicing and operation of the centrifuge, as well as minimizing its impact on other Space Station functions are also considered. Author

A88-29141
SOLAR PLANT GROWTH FACILITY (SPGF) - AN APPROACH TOWARD FUTURE BIOLOGICAL LIFE SUPPORT SYSTEMS
G. SERENTSCHY and G. TRAXLER (Oesterreichische Raumfahrt- und Systemtechnik GmbH, Vienna, Austria) IN: Biological sciences in space 1986; Proceedings of the 1986 International Symposium, Nagoya, Japan, Nov. 10-12, 1986. Tokyo, MYU Research, 1987, p. 306-312.

Studies on the development of an artificially closed ecological system using higher plants as a major constituent and supporting physicochemical subsystems are being conducted. The investigations are directed toward a potential experiment in a low earth orbit using direct sunlight for photosynthesis and biomass production. An operational ground model representing a closed system for the biological specimen has been constructed and is being used for parameter studies; these investigations comprise the analysis of the technical performance of the system, e.g., with respect to the various control loops. Studies to be performed with different types of higher plants are expected to have a substantial importance with respect to the development of future biological life support systems for use in long term manned missions as well as in permanent space structures or stations. Author

N88-10882*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
OVERVIEW OF CREW MEMBER ENERGY EXPENDITURE DURING SHUTTLE FLIGHT 61-B EASE/ACCESS TASK PERFORMANCE
D. J. HORRIGAN, J. W. WALIGORA, J. STANFORD, and B. F. EDWARDS (Technology, Inc., Houston, Tex.) *In* NASA. Langley Research Center, Hampton, Va. Space Construction p 228-235 Oct. 1987
Avail: NTIS HC A14/MF A01 CSCL 22B

The energy expenditure of the Shuttle Flight 61-B crewmembers during the extravehicular performance of Experimental Assembly of Structures in EVA (EASE) and Assembly Concept of Construction of Space Structures (ACCESS) construction system tasks are reported. These data consist of metabolic rate time profiles correlated with specific EASE and ACCESS tasks and crew comments. Average extravehicular activity metabolic rates are computed and compared with those reported from previous Apollo, Shylab, and Shuttle flights. These data reflect total energy expenditure and not that of individual muscle groups such as hand and forearm. When correlated with specific EVA tasks and subtasks, the metabolic profile data is expected to be useful in planning future EVA protocols. For example, after experiencing high work rates and apparent overheating during some Gemini EVAs, it was found useful to carefully monitor work rates in subsequent flights to assess the adequacy of cooling garments and as an aid to preplanning EVA procedures. This presentation is represented by graphs and charts. Author

N88-12520*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACECRAFT FIRE SAFETY
JANICE M. MARGLE, ed. (Pennsylvania State Univ., Abington.) 1987 134 p Workshop held in Cleveland, Ohio, 20-21 Aug. 1986
(NASA-CP-2476; E-3464; NAS 1.55:2476) Avail: NTIS HC A07/MF A01 CSCL 22B

Fire detection, fire standards and testing, fire extinguishment, inerting and atmospheres, fire-related medical science, aircraft fire safety, Space Station safety concerns, microgravity combustion, spacecraft material flammability testing, and metal combustion are among the topics considered.

N88-12521*# National Bureau of Standards, Gaithersburg, Md. Center for Fire Research.
TECHNIQUES FOR FIRE DETECTION
RICHARD W. BUKOWSKI *In* NASA, Lewis Research Center, Spacecraft Fire Safety p 9-29 1987
Avail: NTIS HC A07/MF A01 CSCL 22B

An overview is given of the basis for an analysis of combustable materials and potential ignition sources in a spacecraft. First, the burning process is discussed in terms of the production of the fire signatures normally associated with detection devices. These include convected and radiated thermal energy, particulates, and gases. Second, the transport processes associated with the movement of these from the fire to the detector, along with the important phenomena which cause the level of these signatures to be reduced, are described. Third, the operating characteristics of the individual types of detectors which influence their response to signals, are presented. Finally, vulnerability analysis using predictive fire modeling techniques is discussed as a means to establish the necessary response of the detection system to provide the level of protection required in the application. Author

N88-12522*# National Bureau of Standards, Washington, D.C. Center for Fire Research.
FIRE-RELATED STANDARDS AND TESTING
VYTENIS BABRAUSKAS *In* NASA, Lewis Research Center, Spacecraft Fire Safety p 31-41 1987
Avail: NTIS HC A07/MF A01 CSCL 22B

The state of the art of flammability testing has been changing rapidly. Here, the progress in developing general test methods for solid materials and products exposed to an external fire are reviewed. The special requirements pertinent to environments of concern to NASA are examined and some suggestions for possible directions for future test method developments are given. Author

N88-12523*# Factory Mutual Research Corp., Norwood, Mass.
FIRE EXTINGUISHMENT AND INHIBITION IN SPACECRAFT ENVIRONMENTS
JOHN DERIS *In* NASA, Lewis Research Center, Spacecraft Fire Safety p 43-49 1987
Avail: NTIS HC A07/MF A01 CSCL 22B

It was concluded that it is essential that NASA develop a comprehensive approach to fire extinguishment and inerting in spacecraft environments. Electronic equipment might be easily protected through use of an onboard inert gas generating system. The use of Halon 1301 presents serious technological challenges for agent cleanup and removal of the toxic and corrosive products of combustion. Nitrogen pressurization, while effective, probably presents a serious weight penality. The use of liquid water sprays appears to be the most effective approach to general purpose spacecraft fire protection. Author

N88-12525*# Naval Submarine Medical Research Lab., Groton, Conn.
FIRE-RELATED MEDICAL SCIENCE
DOUGLAS R. KNIGHT *In* NASA, Lewis Research Center, Spacecraft Fire Safety p 59-64 1987
Avail: NTIS HC A07/MF A01 CSCL 22B

Spacecraft fire safety may be improved by the use of a fire-retardant atmosphere in occupied spaces. Low concentrations of oxygen can protect humans from fire damage by reducing the rate and spread of combustion, but care must be taken to avoid the hypoxic effects of oxygen-lean atmospheres. Crews can live and work in 11 percent oxygen if barometric pressure were adjusted to maintain the partial pressure of oxygen above 16 kPa. Eleven percent oxygen should prevent most types of fires, since 15 percent oxygen retards the combustion of paper and 13 percent oxygen extinguishes pentane flames. Test results indicate that seated humans can perform mental tasks in atmospheres containing 11.5 percent oxygen. Although this strategy of fire safety is under consideration for submarines, it could be adapted to spacecraft once operational procedures define a maximum hyperbaric pressure and fire research defines the effects of reduced oxygen concentrations on combustion in low gravity environments.
Author

N88-12527*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION INTERNAL ENVIRONMENTAL AND SAFETY CONCERNS
MATTHEW B. COLE *In* NASA. Lewis Research Center, Spacecraft Fire Safety p 73-87 1987
Avail: NTIS HC A07/MF A01 CSCL 22B

Space station environmental and safety concerns, especially those involving fires, are discussed. Several types of space station modules and the particular hazards associated with each are briefly surveyed. A brief history of fire detection and suppression aboard spacecraft is given. Microgravity fire behavior, spacecraft fire detector systems, space station fire suppression equipment and procedures, and fire safety in hyperbaric chambers are discussed.
R.J.F.

N88-12926*# Presearch, Inc., Houston, Tex.
AN ASSESSMENT OF CLINICAL CHEMICAL SENSING TECHNOLOGY FOR POTENTIAL USE IN SPACE STATION HEALTH MAINTENANCE FACILITY
31 Aug. 1987 306 p
(Contract NAS9-17594)
(NASA-CR-172013; NAS 1.26:172013) Avail: NTIS HC A14/MF A01 CSCL 06K

A Health Maintenance Facility is currently under development for space station application which will provide capabilities equivalent to those found on Earth. This final report addresses the study of alternate means of diagnosis and evaluation of impaired

tissue perfusion in a microgravity environment. Chemical data variables related to the dysfunction and the sensors required to measure these variables are reviewed. A technology survey outlines the ability of existing systems to meet these requirements. How the candidate sensing system was subjected to rigorous testing is explored to determine its suitability. Recommendations for follow-on activities are included that would make the commercial system more appropriate for space station applications. Author

N88-12927*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE SUIT EXTRAVEHICULAR HAZARDS PROTECTION DEVELOPMENT
JOSEPH J. KOSMO Aug. 1987 29 p
(NASA-TM-100458; S-565; NAS 1.15:100458) Avail: NTIS HC A03/MF A01 CSCL 06K

Presented is an overview of the development of the integral thermal/micrometeoroid garment (ITMG) used for protection of a space-suited crewmember from hazards of various extravehicular environments. These hazard conditions can range from thermal extremes, meteoroid and debris particles, and radiation conditions in near-earth orbits and free space to sand and dust environments encountered on lunar and planetary surfaces. Representative ITMG materials cross-section layups are identified and described for various space suit configurations ranging from the Gemini program to planned protective requirements and considerations for anticipated Space Station EV operations. Author

N88-14623*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
AIRBORNE PARTICULATE MATTER IN SPACECRAFT
Feb. 1988 15 p Presented at a Panel Discussion held in Houston, Tex., 23-24 Jul. 1987
(Contract NAS9-17200)
(NASA-CP-2499; S-570; NAS 1.55:2499) Avail: NTIS HC A03/MF A01 CSCL 06K

Acceptability limits and sampling and monitoring strategies for airborne particles in spacecraft were considered. Based on instances of eye and respiratory tract irritation reported by Shuttle flight crews, the following acceptability limits for airborne particles were recommended: for flights of 1 week or less duration (1 mg/cu m for particles less than 10 microns in aerodynamic diameter (AD) plus 1 mg/cu m for particles 10 to 100 microns in AD); and for flights greater than 1 week and up to 6 months in duration (0.2 mg/cu m for particles less than 10 microns in AD plus 0.2 mg/cu m for particles 10 to 100 microns in AD. These numerical limits were recommended to aid in spacecraft atmosphere design which should aim at particulate levels that are a low as reasonably achievable. Sampling of spacecraft atmospheres for particles should include size-fractionated samples of 0 to 10, 10 to 100, and greater than 100 micron particles for mass concentration measurement and elementary chemical analysis by nondestructive analysis techniques. Morphological and chemical analyses of single particles should also be made to aid in identifying airborne particulate sources. Air cleaning systems based on inertial collection principles and fine particle collection devices based on electrostatic precipitation and filtration should be considered for incorporation into spacecraft air circulation systems. It was also recommended that research be carried out in space in the areas of health effects and particle characterization. Author

N88-14868*# Galveston Coll., Tex. Div. of Mathematics and Science.
A SOLID PHASE ENZYME-LINKED IMMUNOSORBENT ASSAY FOR THE ANTIGENIC DETECTION OF LEGIONELLA PNEUMOPHILA (SEROGROUP 1): A COMPLIMENT FOR THE SPACE STATION DIAGNOSTIC CAPABILITY
KELLY E. HEJTMANCIK *In* NASA, Lyndon B. Johnson Space Center, Houston, Tex. NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 1 20 p Nov. 1987
Avail: NTIS HC A15/MF A01 CSCL 06B

It is necessary that an adequate microbiology capability be provided as part of the Health Maintenance Facility (HMF) to support expected microbial disease events and environmental monitoring during long periods of space flight. The application of morphological and biochemical studies to confirm the presence of certain bacterial and fungal disease agents are currently available and under consideration. This confirmation would be facilitated through employment of serological methods to aid in the identification of bacterial, fungal, and viral agents. A number of serological approaches are currently being considered, including the use of Enzyme Linked Immunosorbent Assay (ELISA) technology, which could be utilized during microgravity conditions. A solid phase, membrane supported ELISA for the detection of Legionella pneumophila, an expected disease agent, was developed to show a potential model system that would meet the HMF requirements and specifications for the future space station. These studies demonstrate the capability of membrane supported ELISA systems for identification of expected microbial disease agents as part of the HMF. Author

N88-15365# Stuttgart Univ. (West Germany).
A THEORETICAL CONCEPT FOR STATE CHANGES AND SHAPE CHANGES IN WEIGHTLESSNESS
RETO J. STRASSER *In its* Proceedings and Program Draft in Gravitational Biology in the Federal Republic of Germany (DFVLR-Mitt-85-16) p 17-25 Jun. 1987 Transl into ENGLISH from Gravitationsbiologie in der Bundesrepublik Deutschland-Vortraege und ein Programmentwurf, DFVLR, Cologne (Federal Republic of Germany), Rept. DFVLR-MITT-85-16, Oct. 1985 p 23-31 Original language document was announced as N86-29516
Avail: NTIS HC A07/MF A01; original German version available from DFVLR, Cologne, Fed. Republic of Germany DM 50

A theoretical concept for state and shape changes in weightlessness based on thermodynamics principles for open systems is developed. The influence of light, temperature, pressure, and gravity on the shape and state of a biological system, and therefore on the phonotype with steady genome are studied. Experiments are carried out on leaves, chloroplasts, neurospores and mammalian cell spheroids. An experimental module for cellular biology was built for automatic optical and electrode measurements. The data are recorded, stored, and processed at a ground station. Experiments in space stations are recommended to study the influence of gravity and geomagnetism on the shape and the biochemical processes of a biological system and to obtain data on the phylogenesis of more complicated organisms. ESA

N88-15826# Hernandez Engineering G.m.b.H., Bonn (West Germany).
SAFETY PHILOSOPHY, POLICY, AND REQUIREMENTS FOR MANNED SPACEFLIGHT. VOLUME 1: EXECUTIVE SUMMARY
JAMES WIGGINS Paris, France ESA 4 Mar. 1987 11 p
(Contract ESTEC-6734/86-NL-MA(SC))
(HEG-0886/1036-VOL-1; ESA-CR(P)-2493-VOL-1; ETN-88-91426)
Avail: NTIS HC A03/MF A01

A philosophy and policy for manned space flight and upper level system requirements which would help program managers and system designers include safety considerations in all phases of the program life cycle were designed. The philosophy emphasizes the importance of human life in the space system. ESA

N88-15852*# Texas A&M Univ., College Station. Lab. for Surface Electrochemistry.
ELECTROCHEMICAL PROCESSING OF SOLID WASTE Annual Report
J. OM. BOCKRIS, G. D. HITCHENS, and L. KABA Feb. 1988 42 p
(Contract NAG9-192)
(NASA-CR-182413; NAS 1.26:182413) Avail: NTIS HC A03/MF A01 CSCL 07D

The investigation into electrolysis as a means of waste treatment and recycling on manned space missions is described. The electrochemical reactions of an artificial fecal waste mixture

was examined. Waste electrolysis experiments were performed in a single compartment reactor, on platinum electrodes, to determine conditions likely to maximize the efficiency of oxidation of fecal waste material to CO2. The maximum current efficiencies for artificial fecal waste electrolysis to CO2 was found to be around 50 percent in the test apparatus. Experiments involving fecal waste oxidation on platinum indicates that electrodes with a higher overvoltage for oxygen evolution such as lead dioxide will give a larger effective potential range for organic oxidation reactions. An electrochemical packed column reactor was constructed with lead dioxide as electrode material. Preliminary experiments were performed using a packed-bed reactor and continuous flow techniques showing this system may be effective in complete oxidation of fecal material. The addition of redox mediator Ce(3+)/Ce(4+) enhances the oxidation process of biomass components. Scientific literature relevant to biomass and fecal waste electrolysis were reviewed.
Author

N88-18264# University Hospital, Copenhagen (Denmark). Inst. of Aerospace Medicine.
SCIENTIFIC OBJECTIVES AND FUNCTIONAL REQUIREMENTS OF LIFE SCIENCES IN THE SPACE STATION
F. BONDE-PETERSEN *In* ESA, Proceedings of the 8th ESA Symposium on European Rocket and Balloon Programs and Related Research p 383-385 Aug. 1987
Avail: NTIS HC A21/MF A01

The scientific objectives for research in the Space Station on human physiology and medicine; animal physiology; plant physiology; cellular physiology; radiation biology and exobiology; and bioprocessing are summarized. Requirements for crew intervention and microgravity level are indicated. A pressurized module layout is shown.
ESA

N88-18612*# National Bureau of Standards, Gaithersburg, Md. Center for Fire Research.
SPACECRAFT FIRE DETECTION AND EXTINGUISHMENT: A BIBLIOGRAPHY Final Report
NORA H. JASON Feb. 1988 64 p
(Contract NASA ORDER C-32000-J)
(NASA-CR-180880; NAS 1.26:180880; NBSIR-88-3712; PB88-178553) Avail: NTIS HC A04/MF A01 CSCL 22B

Pertinent fire detection and extinguishment references have been identified to further the knowledge of spacecraft fire safety. To broaden the scope of the bibliography, other unusual environments, e.g., aircraft, submarine, ship, have been included. In addition, for a more comprehensive view of the spacecraft fire safety problem, selected subjects are included, e.g., materials flammability, smoke, human behavior. The references will provide the researcher with access to state-of-the-art and historic works. Selected references from the 1960's have been included, but the emphasis is on references published from 1975 to 1987. The references are arranged by very broad categories. Often a paper will cover more than one topic, but for the purposes of this bibliography it will be cited only once.
Author

N88-19094*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SPACE VEHICLE APPROACH VELOCITY JUDGMENTS UNDER SIMULATED VISUAL SPACE CONDITIONS
RICHARD F. HAINES Aug. 1987 13 p
(NASA-TM-89437; A-87136; NAS 1.15:89437) Avail: NTIS HC A03/MF A01 CSCL 05I

Thirty-five volunteers responded when they first perceived an increase in apparent size of a collimated, 2-D image of an Orbiter vehicle. The test variables of interest included the presence of a fixed angular reticle within the field of view (FOV); three initial Orbiter distances; three constant Orbiter approach velocities corresponding to 1.6, 0.8, and 0.4 percent of the initial distance per second; and two background starfield velocities. It was found that: (1) at each initial range, increasing approach velocity led to a larger distance between the eye and Orbiter image at threshold; (2) including the fixed reticle in the FOV produced a smaller distance between the eye and Orbiter image at threshold; and (3) increasing background star velocity during this judgment led to a smaller distance between the eye and Orbiter image at threshold. The last two findings suggest that other detail within the FOV may compete for available attention which otherwise would be available for judging image expansion; thus, the target has to approach the observer nearer than otherwise if these details were present. These findings are discussed in relation to previous research and possible underlying mechanisms.
Author

N88-19920# Tours Univ. (France). Lab. de Biophysique Medicale.
CARDIOVASCULAR ADAPTATION TO ZERO-G DURING A LONG TERM FLIGHT (237 DAYS) ON BOARD THE SALYUT 7 SOVIET SPACE STATION (1984)
PH. ARBEILLE, J. M. POTTIER, F. PATAT, M. BERSON, A. RONCIN, CH. LETOULLEC, P. MIGNE, L. POURCELOT, A. KATOVSKAYA, O. ATKOV (Institute of Biomedical Problems, Moscow, USSR) et al. *In* ESA, Proceedings of the 3rd European Symposium on Life Sciences Research in Space p 143-146 Dec. 1987
Avail: NTIS HC A15/MF A01

Cardiovascular examinations were performed on three astronauts during a long term flight (234 days). The multimode ultrasound device includes a real-time B mode imaging, a time motion mode, a Doppler and a duplex mode echo-Doppler. This system was used to study the cardiac function and the peripheral circulation. The main hemodynamic parameters (cardiac output, carotid and femoral blood flow, vascular resistances) were measured several times preflight, inflight, and during the recovery period. The individual variations are presented as percentage of the basal preflight value. It is concluded that the hemodynamic changes observed during the flight concern physiological and reversible reactions of the cardiovascular system (e.g., a 20 to 40 percent reduction of left ventricle size).
ESA

N88-19921# Tours Univ. (France). Lab. de Biophysique Medicale.
CARDIAC AND PERIPHERAL CIRCULATION ASSESSMENT BY ULTRASOUND ON 3 ASTRONAUTS DURING TWO 7-DAY SPACE FLIGHTS (1982 SALYUT-7 - 1985 STS 51G)
J. M. POTTIER, F. PATAT, PH. ARBEILLE, A. RONCIN, M. BERSON, and L. POURCELOT *In* ESA, Proceedings of the 3rd European Symposium on Life Sciences Research in Space p 147-149 Dec. 1987
Avail: NTIS HC A15/MF A01

Cardiovascular function was examined by echography on board Salyut 7 and the Space Shuttle. During short flights a moderate increase (maximum + 30 percent) of the left ventricle and the cardiac output followed one day or a few days later by the decrease (maximum - 15 percent) of these parameters are noted. Cerebral circulation remains quite stable whereas the femoral circulation changes with cardiac output. After landing, all the hemodynamic parameters were transiently increased but show large oscillations all along the recovery period. The cardiovascular parameters return to their basal value within a few days. The variations of the main hemodynamic parameters, presented as a percentage of the basal value are compared inflight and postflight.
ESA

N88-19929# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Inst. for Aerospace Medicine.
EUROPEAN ACTIVITIES IN EXOBIOLOGICAL RESEARCH IN SPACE
G. HORNECK *In* ESA, Proceedings of the 3rd European Symposium on Life Sciences Research in Space p 185-192 Dec. 1987
Avail: NTIS HC A15/MF A01

The history of exobiology research is reviewed, and research domains and techniques are described. The relation of cosmic organic compounds to life; interplanetary or interstellar transfer of life; life as a planetary phenomenon; and the physical and chemical boundary conditions for life are considered. European exobiology missions, including exposure of biological systems to components

of free space, EURECA experiments, and exploration of the planetary system are discussed. Space environment simulation experiments are mentioned. ESA

N88-19946# Institute of Biomedical Problems, Moscow (USSR).
MEDILAB: A PROJECT OF A MEDICAL LABORATORY IN SPACE
O. G. GAZENKO, A. I. GRIGORIEV, E. A. ILYIN, and S. F. KHOLIN *In* ESA. Proceedings of the 3rd European Symposium on Life Sciences Research in Space p 275-277 Dec. 1987
Avail: NTIS HC A15/MF A01

A medical laboratory for the Mir Space Station is proposed. Physiological studies concentrate on sensory systems, respiration and circulation regulation, hormonal and fluid-electrolyte metabolism, musculoskeletal system, digestive system, and psychophysiological status. It is planned to study neuro-reflex and neuro-humoral mechanisms of regulation of physiological systems at different time intervals of exposure to microgravity using invasive methods that cannot be applied to man as well as to investigate subtle morphofunctional changes in animals. Biological experiments concentrate on cell biology and population biology to clarify the specific function and evolution of living systems in the absence of gravity and to ascertain the general pattern of gravity effects on living systems. Animal experiments to develop the principles and tactics of surgical manipulations and treatment of pathologies such as local inflammation and wounds, and bone regeneration are planned. ESA

N88-19952# Centre Hospitalier Univ. Rangueil, Toulouse (France).
ANTIBIOTIC ACTIVITY IN SPACE, RESULTS AND HYPOTHESIS
L. LAPCHINE, N. MOATTI, G. RICHOILLEY, J. TEMPLIER, G. GASSET, and R. TIXADOR (Centre Hospitalier Univ. Purpan, Toulouse, France) *In* ESA. Proceedings of the 3rd European Symposium on Life Sciences Research in Space p 305-306 Dec. 1987
Avail: NTIS HC A15/MF A01

Modifications of structure and function of bacteria, particularly in response to antibiotics, induced by spacecraft environments were examined on Spacelab and Salyut. The increase of antibiotic resistance may be due to a stimulating effect on the cell multiplication in space conditions, as reported for several other microorganisms. It may also be due to changes in bacterial cell wall structure and its permeability as proposed by Tixador (1981), in a study of electrolyte content in Paramecium aurelia. It cannot be ruled out that the two hypotheses may have to be combined to explain this phenomenon of transitory increase of resistance in antibiotics. ESA

N88-19964*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ANIMAL RESEARCH ON THE SPACE STATION
S. L. BONTING, R. D. ARNO, and S. D. CORBIN *In* ESA. Proceedings of the 3rd European Symposium on Life Sciences Research in Space p 357-361 Dec. 1987
Avail: NTIS HC A15/MF A01

The need for in-depth, long- and short-term animal experimentation in space to qualify man for long-duration space missions, and to study the effects of the absence and presence of Earth's gravity and of heavy particle radiation on the development and functioning of vertebrates is described. The major facilities required for these investigations and to be installed on the Space Station are: modular habitats for holding rodents and small primates in full biosolation; a habitat holding facility; 1.8 and 4.0 m dia centrifuges; a multipurpose workbench; and a cage cleaner/disposal system. The design concepts, functions, and characteristics of these facilities are described. ESA

21

GENERAL

Includes descriptions, analyses, trade studies, commercial opportunities, published proceedings, seminars, hearings, historical summaries, policy speeches and statements that have not previously been included.

A88-10366*# National Aeronautics and Space Administration, Washington, D.C.
PREPARING FOR THE FUTURE
ANDREW J. STOFAN (NASA, Washington, DC) Aerospace America (ISSN 0740-722X), vol. 25, Sept. 1987, p. 16-18, 20, 22.

Technologies and programs related to the development, construction, and operation of the Space Station are examined. A phase approach has been chosen for the construction of the Space Station, which is to have a revised baseline configuration. Consideration is given to the use of automation on the Space Station; the assembly and servicing of the Station; user requirements; and Space Station operations. The benefits the Space Station will provide to space exploration are discussed. I.F.

A88-10367#
SPACE STATION CAREENS PAST ALL OBSTACLES
JERRY GREY Aerospace America (ISSN 0740-722X), vol. 25, Sept. 1987, p. 24-28.

The difficulties involved in planning the development of the Space Station, in particular federal policies and financing, are described. Concerns about the design and operating characteristics of the Space Station and the support of the Station are examined. The roles of foreign participants (ESA, Japan, Canada) and the U.S. DOD in the development and use of the Space Station are discussed. It is strongly emphasized that a firm national commitment to a unified Space Station policy is needed, and that a Space Station is the key element in virtually every scenario that has been proposed for the U.S. future in space. I.F.

A88-10650
HAS MANNED SPACE FLIGHT A FUTURE?
M. H. HARRISON Spaceflight (ISSN 0038-6340), vol. 29, Sept. 1987, p. 325-328.

The need for manned space flights in the future is argued. The functions humans can perform in space, such as respond to emergencies, improve equipment, and monitor in real time, and the benefits human presence in space will provide are described. Current and proposed uses for space, such as telecommunications, remote sensing, military, and materials processing, are discussed. I.F.

A88-10958*# Texas Univ., Austin.
THE ROLE OF PSYCHOLOGISTS IN FUTURE SPACEFLIGHT
ROBERT L. HELMREICH (Texas, University, Austin) SPACEFAIR '85, Meeting, Boston, MA, Apr. 14, 1985, Paper. 9 p.
(Contract NAG2-137)

The need for psychologists to have a more active role in planning space missions is discussed. It is suggested that it would be beneficial if psychologists conducted research aimed at optimizing the organization, composition, and performance of crews; participated in the selection and training of crews; and monitored the actual performance and adjustment of crews during missions. The areas which require further research and the types of research strategies to be implemented are described. The desirable traits for future space personnel and the role of psychologists in mission control are examined. I.F.

A88-13443
THE COMMERCIAL USE OF SPACE STATIONS: THE LEGAL FRAMEWORK OF TRANS-ATLANTIC COOPERATION; INTERNATIONAL COLLOQUIUM, HANOVER, FEDERAL REPUBLIC OF GERMANY, JUNE 12, 13, 1986, REPORTS [WIRTSCHAFTLICHE NUTZUNG VON WELTRAUMSTATIONEN: DER RECHTLICHE RAHMEN TRANSATLANTISCHER ZUSAMMENARBEIT; INTERNATIONALES KOLLOQUIUM, HANOVER, FEDERAL REPUBLIC OF GERMANY, JUNE 12, 13, 1986, BEITRAEGE]
Colloquium supported by BMFT;. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, 227 p. In German and English. For individual items see A88-13444 to A88-13453.
(Contract BMFT-SLN-86023)
(DGLR BERICHT 86-02)

Papers are presented on the commercial use of space stations; current government-to-government negotiations on the Space Station; an applicable legal regime for international cooperation on space stations; and a legal basis for activities on space stations. Consideration is given to legal problems related to the construction of the Space Stations; national jurisdiction on the Space Station; U.S. legislation governing technology transfer; and a legal regime for technology transfer. Business issues related to materials processing in space and proprietary rights are discussed. I.F.

A88-13445#
NEGOTIATING THE SPACE STATION
MICHAEL A. G. MICHAUD (U.S. Department of State, Washington, DC) IN: The commercial use of space stations: The legal framework of trans-Atlantic cooperation; International Colloquium, Hanover, Federal Republic of Germany, June 12, 13, 1986, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 29-36.

The diplomacy of negotiating international cooperation for a permamently manned Space Station is considered from an American perspective. The negotiations are to be conducted with Europe, Japan, and Canada on two levels: (1) an agency-agency memorandum of understanding and (2) a government-to-government agreement. The principles for the conduct of the negotiations are discussed. The rights, authority, and roles of the partners, and the issue of technology transfer are examined. I.F.

A88-13447#
A LEGAL FRAMEWORK FOR SPACE STATION ACTIVITIES
TADAO KURIBAYASHI (Keio University, Tokyo, Japan) IN: The commercial use of space stations: The legal framework of trans-Atlantic cooperation; International Colloquium, Hanover, Federal Republic of Germany, June 12, 13, 1986, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 63-71.

The development of laws governing Space Station activities is studied. The agreement between NASA and Japan regarding the design and development of the Japanese Experimental Module is examined. Current and proposed laws applicable to the registration, jurisdiction, and control of the Space Station, and the nature and purposes of specific space activities are discussed. It is suggested that disciplinary regulations and safety standards be uniform for all countries participating in the Space Station and experiments, manufacturing, research, and observations be conducted jointly or separately. Consideration is given to proprietary rights, liability for damages, tort laws, and the preservation of the space environment. I.F.

A88-13448#
THE APPLICABLE LEGAL REGIME FOR INTERNATIONAL COOPERATION
I. H. PH. DIEDERIKS-VERSCHOOR (International Institute of Space Law, Paris, France) IN: The commercial use of space stations: The legal framework of trans-Atlantic cooperation; International Colloquium, Hanover, Federal Republic of Germany, June 12, 13, 1986, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 73-85. refs

The applicability of international agreements and United Nations space treaties to space stations operated cooperatively by more than one nation is examined, reviewing several recent proposals and opinions. Topics addressed include the interpretation of Article XII of the Space Treaty of 1967; the composition, duties, and rights of a space station management board; the Liability Convention of 1972; the Convention on Registration of Objects of 1976; and the legal questions posed by multicomponent space stations. T.K.

A88-13450#
NATIONAL JURISDICTION ON THE SPACE STATION
RICHARD DALBELLO (U.S. Congress, Office of Technology Assessment, Washington, DC) IN: The commercial use of space stations: The legal framework of trans-Atlantic cooperation; International Colloquium, Hanover, Federal Republic of Germany, June 12, 13, 1986, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 119-139. refs

Legal questions regarding jurisdiction aboard the International Space Station are discussed from a U.S. perspective. Topics examined include (1) national jurisdiction over the Space Station and/or its components, (2) jurisdiction of courts over specific cases or controversies, (3) choice-of-law questions resulting from the adjudication of Space Station disputes, and (4) the sharing of jurisdiction between the U.S. federal government and the states. It is suggested that international lawyers have some relevant experience regarding areas (2) and (3), but that some rules should probably be developed beforehand due to the highly visible and political nature of international space ventures. Resolution of the primarily political and technological conflicts foreseen in area (1) by mechanisms similar to NATO Status of Forces Agreements is recommended, and the need for Congressional limits on state legislation to prevent problems in area (4) is indicated. T.K.

A88-13451#
BUSINESS ISSUES OF MATERIALS PROCESSING IN SPACE
JOHN J. EGAN (Coopers and Lybrand, Washington, DC) IN: The commercial use of space stations: The legal framework of trans-Atlantic cooperation; International Colloquium, Hanover, Federal Republic of Germany, June 12, 13, 1986, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 175-180.

The complementary roles of government and business in developing commercial materials processing in space (MPS) are discussed. The potentially long duration, high cost, and risk of the development phase of a typical MPS venture are emphasized, and the political implications are indicated. A number of ways in which the U.S. government could act to encourage commercial MPS programs (a NASA policy goal) are considered, including elimination of tax and import/export barriers, construction and maintenance of a space infrastructure (the Space Station) with some support from user fees, opportunity for proof-of-concept experiments on MPS technologies, and clear and fair regulation of space-laboratory management questions. T.K.

A88-13452#
LEGAL PROBLEMS OF THE COMMERCIAL USE OF SPACE STATIONS INCLUDING PROPRIETARY RIGHTS
CLAUDIO ZANGHI (Ministero di Ricerca Scientifica e Technologica, Rome, Italy) and LUIGI CITARELLA (Roma, Universita, Rome, Italy) IN: The commercial use of space stations: The legal framework of trans-Atlantic cooperation; International Colloquium, Hanover, Federal Republic of Germany, June 12, 13, 1986, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 181-200.

Potential legal questions arising from commercial activities aboard an international space station are examined in a general review. The lack of clearly defined regulations governing stations made up of component modules belonging to different nations is stressed, and it is argued that simple application of national jurisdictions over activities on each module is unrealistic. A system of international regulations based on pragmatic (cost) factors is recommended, and possible provisions of such an agreement are discussed. T.K.

A88-13453*# National Aeronautics and Space Administration, Washington, D.C.
PROPRIETARY RIGHTS AND COMMERCIAL USE OF SPACE STATIONS
ROBERT F. KEMPF (NASA, Washington, DC) IN: The commercial use of space stations: The legal framework of trans-Atlantic cooperation; International Colloquium, Hanover, Federal Republic of Germany, June 12, 13, 1986, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 201-216.

The treatment of proprietary rights related to commercial activity aboard an international space station is discussed, with a focus on the relationship between the acquisition (on earth or in space) and protection of such rights. The applicable national and international law is briefly characterized, and consideration is given to patent, trade-secret, and copyright considerations. It is concluded that the provisions of present commercial law can be applied relatively straightforwardly to rights acquired on earth, while the Outer Space Treaty of 1967 and the Convention on Registration of 1976 apply to rights obtained in space. T.K.

A88-15276
SPACE CONGRESS, 24TH, COCOA BEACH, FL, APR. 21-24, 1987, PROCEEDINGS
Congress sponsored by the Canaveral Council of Technical Societies. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1987, 656 p. For individual items see A88-15277 to A88-15314.

Topics covered include space colonization, European technology development, expendable launch vehicles in the USA and Europe, Space Station technologies, Space Station servicing, and Columbus and Eureca. Consideration is also given to second generation STS/launch vehicle technology, computers, contracts and management, and technology spinoffs. B.J.

A88-15480#
COMMERCIAL LAUNCH SYSTEMS - THE FORESEEABLE FUTURE FOR AUSSAT
G. H. S. PIKE (AUSSAT Pty., Ltd., Sydney, Australia) IN: National Space Engineering Symposium, 2nd, Sydney, Australia, Mar. 25-27, 1986, Preprints. Volume 1. Barton, Australia/Brookfield, VT, Institution of Engineers, Australia/Brookfield Publishing Co., 1986, 11 p.

This paper provides an overview of the launch vehicle systems which are likely to be available to launch medium sized communications spacecraft during the 1990's. Both existing and proposed systems are covered, including the appropriate upper stages for the U.S. Space Transportation System. It is concluded that the second generation of Aussat spacecraft will use essentially existing systems but benefit from major advances in the commercial aspects of launch procurements. The third generation should have a wide variety of new vehicles to choose from as a result of new and innovative launch vehicle developments around the world. Author

A88-15807*# National Aeronautics and Space Administration, Washington, D.C.
SPACECRAFT TECHNOLOGY TRENDS - A VIEW FROM THE PAST
WAYNE R. HUDSON (NASA, Office of Aeronautics and Space Technology, Washington, DC) and CHARLES F. GARTRELL (General Research Corp., Aerospace Systems Group, McLean, VA) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 13 p. refs
(IAF PAPER 87-07)

Future spacecraft will be sent on missions to complete the exploration of the solar system, to return samples from celestial bodies, record the process of creation of stars, galaxies, and the universe itself, to provide a continuous record of earth processes, and to maintain vital space communications. A key ingredient to projecting the future is to comprehend the historic record and to understand the significance of trends. This paper focuses on spacecraft cost and life trends, as well as those of the major subsystems. Throughout the history of the 'space age' there has been significant progress in the performance of spacecraft and their subsystems. However, various aspects of spacecraft performance lag behind what is technically feasible by a considerable margin. In addition, examination of the historical trend implies that future spacecraft will likely continue to be relatively unique in their design features. This is in contrast to the technically realizable future attributes such as large space platforms, modularity, system autonomy and on-orbit repair and servicing. Author

A88-15833*# National Aeronautics and Space Administration, Washington, D.C.
TECHNOLOGY - THE BASIS FOR THE PAST, THE KEY TO THE FUTURE
LEONARD A. HARRIS and RAYMOND S. COLLADAY (NASA, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 8 p.
(IAF PAPER 87-47)

The relationship between new technology and space missions, and the objectives of the Civil Space Technology Initiative (CSTI) are studied. The CSTI is concerned with technologies for safe and efficient access to space, earth-orbiting operations, and future science missions. The initiative focuses on research in the areas of propulsion, vehicles, information systems, large space structures and their control, power, and automation and robotics. Consideration is given to the development of high-performance engines for next-generation vehicles, booster technology for hybrid and pressure-fed propulsion systems, and a space OTV based on the aerobrake concept. Research involved with the application of automation and robotics to earth-orbiting operations are discussed. The control of flexible structure flight experiment, the use of nuclear systems for space propulsion, and the development of sensor devices and high-rate, high-capacity data systems are examined. I.F.

A88-15840*# National Aeronautics and Space Administration, Washington, D.C.
A RESEARCH LABORATORY IN SPACE
ANDREW J. STOFAN (NASA, Office of Space Station, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 6 p.
(IAF PAPER 87-60)

The current status of the Space Station program is briefly reviewed. A three-year definition and preliminary design study, now completed, has produced the Revised Baseline Configuration featuring a 110-m-long horizontal boom with four pressurized models attached that are connected by resource nodes outfitted with Station subsystems. One of the modules is a habitat; the other three are laboratories provided by the U.S., Europe, and Japan. The main components and systems of the Revised Baseline Configuration are characterized, and some aspects of project management and international cooperation are discussed. V.L.

A88-15843*# National Aeronautics and Space Administration, Washington, D.C.
NASA AND THE SPACE STATION - CURRENT STATUS
THOMAS L. MOSER (NASA, Office of Space Station, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 6 p.
(IAF PAPER 87-64)

In the baseline configuration of the Space Station, NASA engineers have provided for a range of modifications that will enlarge the capabilities available to future users. An extensive definition and design study has been completed which is supplemented by a critical evaluation of the Space Station configuration; a three-year technology-development effort has also drawn to a close which examined operational factors and restructured program management responsibilities. Costs have been estimated on the basis of the revised configuration in order to insure full consistency for program funding plans. O.C.

A88-15844*# National Aeronautics and Space Administration, Washington, D.C.
UNITED STATES SPACE STATION TECHNICAL AND PROGRAMMATIC INTERFACES
RICHARD F. CARLISLE and WILLIAM E. RICE (NASA, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 15 p.
(IAF PAPER 87-65)

This paper describes the design of the U.S. Space Station and explains the control factors used for internal and external interfaces among the various government and contractor participants. It discusses the documentation of the U.S. Space Station Program including the Program Approval Document (PAD), the Program Plans (PPs), the Program Requirements Document (PRD), the Program Definition and Requirements Document (PDRD), the Level III project plans, and the Level III project design requirements documents. It discusses the relationship of Space Station documentation to the international Memoranda of Understanding (MOUs) and the Joint PP, PRD, and PDRD, the interrelationship of the Architectural Control Documents (ACDs), the Baseline Control Document (BCD), and the Interface Requirement Documents (IRDs) and Interface Control Documents (ICDs). Also included are the controlling functions of the various NASA and contractor participants and the international partners. Author

A88-15852#
MAN IN SPACE
V. A. SOLOV'EV (Mission Control Centre, Moscow, USSR) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 4 p.
(IAF PAPER 87-77)

Some of the EVA operations performed by the cosmonauts on Salyut 7 are described. The EVAs involved: (1) repairing the propulsion system; (2) installing additional solar cells; and (3) installing and testing a truss structure deployed on the station surface. The need for specific tools for these operations and the difficulty of the activities performed are discussed. I.F.

A88-15855*# National Aeronautics and Space Administration, Washington, D.C.
THE UNITED STATES SPACE STATION REVISED BASELINE
RAYMOND ROBERTS (NASA, Space Station Program Office, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 12 p.
(IAF PAPER 87-81)

This paper describes the current U.S. Space Station baseline configuration. The Space Station Revised Baseline (IAF-87-81) includes an historical perspective, a rationale for the current configuration, definitions of major Space Station and international elements and distributed systems, functional descriptions of the Space Station at key milestones in its construction, and possible directions for Station growth. Author

A88-15869#
THE UTILISATION OF THE COLUMBUS POLAR PLATFORM
C. P. LEE (British Aerospace, PLC, Space and Communications Div., Bristol, England) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 11 p. refs
(IAF PAPER 87-98)

This paper presents the results of a 16 month investigation into the potential opportunities and constraints raised by the utilization of the Columbus Polar Platform. Several themes are addressed, including payload engineering, operations, mission planning, user support and programmatics. Both pre and post flight phases are described. While the platform itself has undergone important modifications since the completion of the study, particularly the servicing strategy, results nevertheless confirm the technical viability of utilization. It concludes that any utilization organization should support rather than lead the user community, who are found to be both mature and accessible. Author

A88-15944*# Washington Univ., Seattle.
RAM ACCELERATOR DIRECT LAUNCH SYSTEM FOR SPACE CARGO
A. P. BRUCKNER and A. HERTZBERG (Washington, University, Seattle) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 12 p. refs
(Contract NAG1-746)
(IAF PAPER 87-211)

The ram accelerator, a chemically-propelled mass driver, is presented as a new approach for directly launching acceleration-insensitive pay-loads into LEO. The cargo vehicle resembles the centerbody of a conventional ramjet and travels through a launch tube filled with a premixed gaseous fuel and oxidizer mixture. The tube acts as the outer cowling of the ramjet and the combustion process travels with the vehicle. Two modes of ram accelerator drive are described, which when used in sequence, are capable of accelerating the cargo vehicle to 10 km/sec. The requirements for placing a 2000 kg vehicle with 50 percent payload fraction into a 400 km orbit, with a minimum of on-board rocket propellant for circularization maneuvers, are examined. It is shown that aerodynamic heating during atmospheric transit results in very little ablation of the nose. Both direct and indirect orbital insertion scenarios are investigated, and a three-step maneuver consisting of two burns and aerobraking is found to minimize the on-board propellant mass. A scenario involving a parking orbit below the desired final orbit is suggested as a means to increase the flexibility of the mass launch concept. Author

A88-16074#
THIRTY YEARS OF THE SPACE AGE
B. V. RAUSHENBAKH (AN SSSR, Moscow, USSR) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987, Paper. 9 p.

The history of space science and technology in the 30 years since the launch of Sputnik is surveyed. The early history of rocketry is reviewed, and consideration is given to the crucial role of multistage rocket boosters in the beginning of space flight, the focus on manned missions in the late 1950s and 1960s, and the more pragmatic orientation of the space programs in the 1970s and 1980s. It is predicted that the predominant space activity in the near future will be the construction and industrial utilization of large manned space stations. T.K.

A88-16146#
EDUCATIONAL AND PEDAGOGICAL IMPORTANCE OF ASTRONAUTICS
WLADYSLAW GEISLER and KRYSTYNA LUKASIK (Polskie Towarzystwo Astronautyczne, Katowice, Poland) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 6 p.
(IAF PAPER 87-520)

The benefits provided to man by astronautics are discussed. Particular emphasis is given to the effect of future astronautical activities on the education and development of youth. The evolution of space flight, the development of spacecraft, and advances in space capabilities are examined. Some of the U.S. and USSR manned missions and experiments are described. Consideration is given to artificial satellites, space probes, space stations, and extending space flights. I.F.

A88-16150#
MAN IN SPACE FLIGHT
O. G. GAZENKO, E. B. SHUL'ZHENKO, A. I. GRIGOR'EV, and A. D. EGOROV (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 8 p. refs
(IAF PAPER 87-527)

Physiological changes that occur in man during spaceflight are examined. The mechanisms which cause these main physiological changes, such as a change in the afferent load, the elimination of hydrostatic pressure, and the lack of weight load on the musculoskeletal system, are discussed, and methods for countering these mechanisms are described. Changes in man's vestibular

functions, motor system, fluid-electrolyte metabolism, cardiovascular system, calcium metabolism, circulatory system, and immunology system during spaceflight are considered. I.F.

A88-16211#
COSTS AND BENEFITS OF FUTURE HEAVY SPACE FREIGHTERS
H. AREND (Berlin, Technische Universitaet, Federal Republic of Germany) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 10 p.
(IAF PAPER 87-617)

A class of two-stage reusable ballistic Space Freighters with nominal launch masses of 7000 metric tons for transport of heavy payloads into low earth orbits is investigated in this paper with spcial regard to vehicle cost efficiency. A life-cycle cost analysis shows that Space Freighters with a conventional aluminum structure offer significantly lower specific transportation costs than today's systems for large payload markets and high launch rates. Advanced structural materials and thermal protection systems offer further important reductions not only with regard to vehicle mass but also with respect to specific transportation cost. A phased introduction of these technologies is cost efficient for larger programs with more than 100 vehicles. Author

A88-16215*# Ford Aerospace and Communications Corp., Palo Alto, Calif.
ECONOMIC BENEFITS OF THE SPACE STATION TO COMMERCIAL COMMUNICATION SATELLITE OPERATORS
KENT M. PRICE, JOHN E. DIXSON, and CHARLES J. WEYANDT (Ford Aerospace and Communications Corp., Western Development Laboratories Div., Palo Alto, CA) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 8 p.
(Contract NAS3-24253)
(IAF PAPER 87-622)

The economic and financial aspects of newly defined space-based activities, procedures, and operations (APOs) and associated satellite system designs are presented that have the potential to improve economic performance of future geostationary communications satellites. Launch insurance, launch costs, and the economics of APOs are examined. Retrieval missions and various Space Station scenarios are addressed. The potential benefits of the new APOs to the commercial communications satellite system operator are quantified. C.D.

A88-16223#
STATION PRICING - NOT JUST A QUESTION OF 'HOW MUCH DOES IT COST?'
JOHN J. EGAN (The Egan Group, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 6 p.
(IAF PAPER 87-631)

Aspects of Space Station pricing policy are discussed. The purpose of pricing is reviewed, and the use of pricing to influence customer behavior is discussed. Pricing methodology is addressed, and the issue of who pays is examined. C.D.

A88-16243*# National Aeronautics and Space Administration, Washington, D.C.
LONG RANGE PLANNING AT NASA
IVAN BEKEY (NASA, Program Planning, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 7 p.
(IAF PAPER 87-670)

NASA's current plans for the U.S. space program are described. Consideration is given to the debate between manned or unmanned exploration of space, missions to the moon versus missions to Mars, and the exploration of space applications or science. NASA has created the Office of Policy and Planning and the Office of Exploration in order to improve the planning of future space activities. Long-range trends such as second-generation Shuttles, cargo launch vehicles with large capacity systems, an advanced Space Station, the use of robotics, closed cycle life support, health maintenance techniques, and the processing of extraterrestrial materials are considered. I.F.

A88-22000
PROCEEDINGS OF THE FOURTH ANNUAL L5 SPACE DEVELOPMENT CONFERENCE
FRANK HECKER, ED. (L-5 Society, Tucson, AZ) San Diego, CA (Science and Technology Series. Volume 68), Univelt, Inc., 1987, 268 p. No individual items are abstracted in this volume.

Scientific, technological, and political aspects of present and planned U.S. space activities are discussed in reviews and reports. Topics addressed include space and U.S. politics, space resources, international space ventures, space-age education, and space biomedicine. Consideration is given to communities in space, space tourism, the 'pure' space sciences, and the cultural drive for space. Diagrams, drawings, graphs, photographs, and tables of numerical data are provided. T.K.

A88-22255#
MATERIALS PROCESSING TWIN EXPERIMENT
ERNST STUHLINGER and TRIP MOOKHERJI (Teledyne Brown Engineering, Huntsville, AL) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 7 p. refs
(AIAA PAPER 88-0348)

While the adverse effects of acceleration forces upon the growth of 'perfect' crystals were recognized long ago, it is still not known how low an acceleration, as a function of frequency, should be to permit the undisturbed growth of crystals. The proposed twin experiment is considered a first step toward answering that question. Two identical crystal growth experiments will be carried out simultaneously onboard a spacecraft; the first will be mounted directly to the spacecraft structure, the second will be suspended by soft springs that filter out all disturbances above a specified acceleration and frequency. Accelerometers attached to each experiment will measure and record the accelerations encountered by each experiment. After-flight comparisons of the two crystals will provide an indication of the effects caused by two different levels of accelerations. Author

A88-22328#
FROM SPACE SHUTTLE TO SPACE STATION - GRADUATING FROM PAPER TO ELECTRONIC MEDIA
GORDON L. JOHNS (Mitre Corp., Houston, TX) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(AIAA PAPER 88-0442)

A dynamic user interface is suggested for the electronically-generated graphics being developed to supplant paper information media in Space Station operations; this interface is claimed to offer smart, responsive assistance that can render procedure execution faster, more accurate, and more acceptable to crew members than fixed-geometry displays. The central concept of the proposed system is that real-time software can extract information from an operations data base and construct a detailed display indicating precisely what procedural steps and support data must be displayed at each stage of execution. O.C.

A88-22567#
SPACEWARD HO
JOHN F. YARDLEY (McDonnell Douglas Astronautics Co., Saint Louis, MO) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 7 p.
(AIAA PAPER 88-0750)

The paper compares the differences between the U.S. and Soviet space programs in the past 30 years to determine what steps the U.S. can take to regain its leadership position in space. After briefly examining the space flight technology and the development processes utilized by the two space programs, it is suggested that the U.S. become more evolutionary in its programs and more streamlined in its development practices. Most important, however, is the gaining of public support for a robust, long-range space plan. The key is effective communication with the American

people; it is suggested that the AIAA take the lead in organizing this communication thrust. Author

A88-22957
OFF TO SEE THE WIZARD
GARY GRAF Space World (ISSN 0038-6332), vol. X-4-280, April 1987, p. 26-29.

A redesigned spacesuit is considered to be a necessary complement to the Space Station. The new suit is to operate at the Station's constant pressure of one earth atmosphere, and should be maintainable in orbit. Experiments conducted at NASA-Ames have led to the belief that the suit should be made entirely out of metal or other rigid material with joints of reinforced fabric or metal to give the astronaut the mobility needed for space work. K.K.

A88-23925#
THE CIVIL SPACE PROGRAM: AN INVESTMENT IN AMERICA - REPORT OF AN AIAA WORKSHOP
Washington, DC, American Institute of Aeronautics and Astronautics, 1987, 64 p. refs

In the interest of formulating a strategic view of U.S. civil space systems' development, the AIAA convened a workshop to review current and prospective commitments of NASA and other competent agencies. Such goals as the creation of space-based global information systems and the agressive development of space-processed industrial products require the intensive funding of space infrastructure resources. These resources will encompass space stations and platforms, lunar/planetary bases, and larger space transportation systems employing more advanced technology than the current Space Shuttle. O.C.

A88-26197
COLLOQUIUM ON THE LAW OF OUTER SPACE, 28TH, STOCKHOLM, SWEDEN, OCT. 7-12, 1985, PROCEEDINGS
Colloquium sponsored by IAF. New York, American Institute of Aeronautics and Astronautics, 1986, 317 p. No individual items are abstracted in this volume.

The legal implications of recent advances in space technology and exploitation are explored in reviews and reports. The emphasis is on efforts to limit military activities in space, but consideration is also given to comparisons of sea law and space law governing exploration and exploitation, the legal problems of registering space objects, and particular space activities as the subjects of space law. Topics addressed include nuclear winter, ballistic missile defense, and the legal regime for outer space; space law and space offensive weapons; an interdisciplinary approach to the SDI debate; the effect of fiber-optic communication on space radio regulations; the registration treaty and nuclear power sources; protecting the security of space traffic; the problem of orbital debris; plans for the International Space Station; and technicolegal and medicolegal aspects of manned space stations. T.K.

A88-27584*# Ford Aerospace and Communications Corp., Palo Alto, Calif.
THE ECONOMICS OF SATELLITE RETRIEVAL
KENT M. PRICE (Ford Aerospace and Communications Corp., Space Systems Div., Palo Alto, CA) and JOEL S. GREENBERG (Princeton Synergetics, Inc., NJ) IN: AIAA International Communication Satellite Systems Conference, 12th, Arlington, VA, Mar. 13-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 496-510.
(Contract NAS3-24253)
(AIAA PAPER 88-0843)

The economics of space operations with and without the Space Station have been studied in terms of the financial performance of a typical communications-satellite business venture. A stochastic Monte-Carlo communications-satellite business model is employed which includes factors such as satellite configuration, random and wearout failures, reliability of launch and space operations, stand-down time resulting from failures, and insurance by operation. Financial performance impacts have been evaluated in terms of the magnitude of investment, net present value, and return on investment. R.R.

A88-27656
A 50 YEAR SCENARIO FOR THE UTILIZATION OF SPACE TO IMPROVE THE QUALITY-OF-LIFE ON EARTH
H. H. KOELLE (Berlin, Technische Universitaet, Federal Republic of Germany) IN: Norderney Symposium on Scientific Results of the German Spacelab Mission D1, Norderney, Federal Republic of Germany, Aug. 27-29, 1986, Proceedings. Cologne, Federal Republic of Germany, Wissenschaftliche Projektfuehrung D1, 1987, p. 68-90. refs

The history of space programs is briefly reviewed, and future activities aimed primarily at improving life on earth are discussed and illustrated with extensive diagrams, flow charts, and tables. The economic and political factors affecting future space programs and the criteria to be considered in evaluating the quality of life are listed; the humanistic, political, scientific, and utilitarian objectives of space activities are examined; and a scenario involving matter, energy, and information objectives is outlined. Particular attention is given to the limitations imposed by current launch vehicles, the potential of projected SSTO and HLLV configurations, and the features of planned space infrastructures such as the International Space Station. T.K.

A88-27954
U.S. SPACE PLATFORM FIRMS AIM FOR 1991 SERVICE START
THERESA M. FOLEY Aviation Week and Space Technology (ISSN 0005-2175), vol. 128, Feb. 29, 1988, p. 36-38,41.

Two private firms must close deals in the first half of 1988 with their respective investors, and begin constructing hardware shortly thereafter, if space operations of their pressurized space modules are to begin on schedule in the early 1990s. One of the two firms will construct an Industrial Space Facility, at an estimated cost of $700 million; the other will produce 'Spacehab', a pressurized module small enough to fly in the Space Shuttle Cargo Bay. The projected cost of building and testing the first two Spacehab modules and associated ground facilities is $65-70 million. O.C.

A88-29107
SPACE LIFE SCIENCES IN JAPAN
GENYO MITARAI (Chukyo University, Toyota, Japan) IN: Biological sciences in space 1986; Proceedings of the 1986 International Symposium, Nagoya, Japan, Nov. 10-12, 1986. Tokyo, MYU Research, 1987, p. 25-37. refs

Space life sciences (LSs) research activity of Japan is reviewed, and the present status of the twelve LS experiments planned for the First Materials Processing Test planned to be conducted aboard the Space Station is discussed. The experiments planned for the FMPT projects include studies on endocrine and metabolic changes and on visual stability in space, a neurophysiological study of posture control in fish, studies of the effect of microgravity on the development and formation of bone tissue, and studies on the genetic effects of HZE and cosmic radiation. Other experiments will include investigations on crystal growth in zero gravity, utrastructural changes of cells in culture, the circadian rhythm of fungus, the electrophoretic separation of cells, and the efficiency of protein electrophoresis in zero gravity. I.S.

A88-29410
MANKIND AND SPACE [CHELOVECHESTVO I KOSMOS]
OLEG GEORGIEVICH GAZENKO, IGOR' DMITRIEVICH PESTOV, and VLADIMIR IVANOVICH MAKAROV Moscow, Izdatel'stvo Nauka, 1987, 272 p. In Russian. refs

The development of space exploration and manned space flight is considered with particular emphasis on the biomedical aspects. Results of medical, biological, and psychological investigations during space flight are summarized. Hypotheses on human biological evolution are examined in connection with the colonization of space. The so-called transforming effect of space

programs on nature, economics, and social relations is discussed, and the role of international cooperation in space exploration is considered. B.J.

N88-10072*# National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION: LEADERSHIP FOR THE FUTURE
FRANKLIN D. MARTIN and TERENCE T. FINN 1987 10 p Original contains color illustrations
(NASA-PAM-509/8-87) Avail: NTIS HC A02/MF A01 CSCL 22B

No longer limited to occasional spectaculars, space has become an essential, almost commonplace dimension of national life. Among other things, space is an arena of competition with our allies and adversaries, a place of business, a field of research, and an avenue of cooperation with our allies. The space station will play a critical role in each of these endeavors. Perhaps the most significant feature of the space station, essential to its utility for science, commerce, and technology, is the permanent nature of its crew. The space station will build upon the tradition of employing new capabilities to explore further and question deeper, and by providing a permanent presence, the station should significantly increase the opportunities for conducting research in space. Economic productivity is, in part, a function of technical innovation. A major thrust of the station design effort is devoted to enhancing performance through advanced technology. The space station represents the commitment of the United States to a future in space. Perhaps most importantly, as recovery from the loss of Challenger and its crew continues, the space station symbolizes the national determination to remain undeterred by tragedy and to continue exploring the frontiers of space. B.G.

N88-10085*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACECRAFT 2000 PROGRAM OVERVIEW
ROBERT W. BERCAW *In its* Spacecraft 2000 p 1-6 Jul. 1986
Avail: NTIS HC A11/MF A01 CSCL 22B

The goals are to identify the critical need and technologies for spacecraft of the 21st century, and to recommend technology development and validation programs and possible government/industrial roles and partnerships. The objectives of the workshop are to increase awareness and exchange ideas among participants, highlight the spacecraft as a focal point for technology, and facilitate industry-government coordination. B.G.

N88-10091*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACECRAFT SYSTEMS WORKING GROUP REPORT
JOHN E. KEIGLER (RCA Astro-Electronics Div., Princeton, N. J.) and LARRY F. ROWELL *In* NASA-Lewis Research Center, Spacecraft 2000 p 85-107 Jul. 1986
Avail: NTIS HC A11/MF A01 CSCL 22B

Issues addressed include: definition of user/commercial/government needs by function; criteria for prioritization of needs; overall criteria for technology assessment; system configuration drivers (key trade studies); space infrastructure interface; and cost drivers (pros and cons of standardization, manufacturing, test, serviceability, and supportability). B.G.

N88-10844*# Reliance Electric Co., Worthington, Ohio.
MOVING THE FACTORY INTO ORBIT
ROBERT DANNENFELSER, JR. *In* NASA- Goddard Space Flight Center, Greenbelt, Md. Fourteenth Space Simulation Conference: Testing for a Permanent Presence in Space p 163-174 1986
Avail: NTIS HC A19/MF A01 CSCL 22B

Prompted by the attention focused on the Space Shuttle Program's cost and safety problems and the publicity surrounding the intended U.S. space station, a review is given of the status of efforts being made to use space as a commercial manufacturing environment. Author

N88-10883# General Accounting Office, Washington, D. C. National Security and International Affairs Div.
SPACE STATION: NATIONAL AERONAUTICS AND SPACE ADMINISTRATION'S 1987 COST ESTIMATE
Jul. 1987 20 p
(PB87-220760; NSIAD-87-180FS; B-227537) Avail: NTIS HC A03/MF A01 CSCL 22B

The report examines the coverage and methodology of the National Aeronautics and Space Administration (NASA) space station cost review to explain how NASA had compiled and analyzed the data to support the cost estimate and to identify the categories of included costs. The GAO presented the results of the work in a briefing on 15 April 1987. The fact sheet summarizes and updates the information contained in that briefing. GRA

N88-11944*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN ALLOTMENT PLANNING CONCEPT AND RELATED COMPUTER SOFTWARE FOR PLANNING THE FIXED SATELLITE SERVICE AT THE 1988 SPACE WARC
EDWARD F. MILLER, ANN O. HEYWARD, DENISE S. PONCHAK, RODNEY L. SPENCE, WAYNE A. WHYTE, JR., and JOHN E. ZUZEK Nov. 1987 12 p Presented at the Global Telecommunications Conference, Tokyo, Japan, 15-18 Nov. 1987; sponsored by IEEE
(NASA-TM-100244; E-3777; NAS 1.15:100244) Avail: NTIS HC A03/MF A01 CSCL 17B

Described is a two-phase approach to allotment planning suitable for use in establishing the fixed satellite service at the 1988 Space World Administrative Radio Conference (ORB-88). The two phases are (1) the identification of predetermined geostationary arc segments common togroups of administrations, and (2) the use of a synthesis program to identify example scenarios of space station placements. The planning approach is described in detail and is related to the objectives of the conference. Computer software has been developed to implement the concepts, and a complete discussion on the logic and rationale for identifying predetermined arc segments is given. Example scenarios are evaluated to give guidance in the selection of the technical characteristics of space communications systems to be planned. The allotment planning concept described guarantees in practice equitable access to the geostationary orbit, provides flexibility in implementation, and reduces the need for coordination among administrations. Author

N88-12132# European Space Agency, Paris (France).
POSSIBLE COMMERCIAL USE OF THE POLAR PLATFORMS
ANNE-MARIE HIERONIMUS *In its* Commercial Opportunities for Remote Sensing with Polar Platforms p 7-9 Apr. 1987
Avail: NTIS HC A05/MF A01

Conditions to be fulfilled for commercial use of the Columbus Polar Platforms are outlined. The legal position, selection procedures, and pricing policy are discussed. ESA

N88-12138# Logica Ltd., Cobham (England).
COMMERCIAL PERSPECTIVE OF AN IMAGING SPECTROMETER DEVELOPMENT PROGRAM
D. C. FERNS *In* ESA, Commercial Opportunities for Remote Sensing with Polar Platforms p 49-54 Apr. 1987
Avail: NTIS HC A05/MF A01

The costs of commercial payload development programs are shown to be orders of magnitude greater than the revenue that might be expected from image and data product sales. The criteria by which an instrument is judged to have commercial potential are defined, and the reasons for the choice of an imaging spectrometer are given. ESA

N88-12422# Committee on Science and Technology (U.S. House).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AUTHORIZATION ACT, 1988
Washington GPO 1987 19 p H.R. 2782 enacted into law by

the 100th Congress, 2d session, 30 Oct. 1987
(PUB-LAW-100-147) Avail: US Capitol, House Document Room

Appropriations were authorized to the National Aeronautics and Space Administration for research and development; space flight, control, and data communications; constructions of facilities; and research and program management; and for other purposes.
Author

N88-12424# Committee on Appropriations (U.S. Senate).
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT-INDEPENDENT AGENCIES APPROPRIATIONS FOR FISCAL YEAR 1988, THURSDAY, 9 APRIL 1987: NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
In its Department of Housing and Urban Development, and Certain Independent Agencies Appropriations, 1988, Part 2 p 1019-1115 1987
Avail: Committee on Appropriations

Oral and written statements of the NASA Administrator before the subcommittee are presented, as well as written questions and responses to them. Areas of emphasis include plans for an orbital space station and heavy lift launch capability.
J.P.B.

N88-12425# Committee on Appropriations (U.S. Senate).
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT-INDEPENDENT AGENCIES APPROPRIATIONS FOR FISCAL YEAR 1988, FRIDAY, 10 APRIL 1987: NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
In its Department of Housing and Urban Development, and Certain Independent Agencies Appropriations, 1988, Part 2 p 1117-1197 1987
Avail: Committee on Appropriations

Oral and written testimony of the NASA Administrator before the subcommittee is presented. The emphasis is on plans for an orbital space station, heavy lift launch vehicles, the resumption of shuttle flights, the Hubble Space Telescope, and aircraft energy efficiency. Some attention is given to other NASA space exploration and new technology programs.
J.P.B.

N88-14043# Committee on Appropriations (U.S. Senate).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION SPACE STATION PROPOSAL, FISCAL YEAR 1988
Washington GPO 1987 281 p Hearings before the Committee on Appropriations, 100th Congress, 1st Session, 1 and 20 May 1987
(S-HRG-100-328; GPO-76-948) Avail: Committee on Appropriations

Hearings were held to ascertain non-NASA expert opinion on the advisability of and options for a U.S. orbital space station. Scientists, academics, engineers, and businessmen expressed opinions on the desirability of funding a space station as opposed to other possible space priorities. The second day of hearings concentrated on opinions regarding the commercial potential of a space-station.
J.P.B.

N88-14044# Committee on Science, Space and Technology (U.S. House).
THE 1988 NASA (NATIONAL AERONAUTICS AND SPACE ADMINISTRATION) AUTHORIZATION
Washington GPO 1988 77 p Hearing before the Subcommittee on Space Science and Applications of the Committee on Science, Space and Technology, 100th Congress, 1st Session, No. 43, 8 Apr. 1987
(GPO-80-245) Avail: Subcommittee on Space Science and Applications

Space Stations configuration and cost reviews are discussed in terms of the commitment of the United States to a permanently manned Space Station. Congressional approval to release Request for Proposals to industry for a phased development of the space station is sought, including estimates for an enhanced capability configuration. Also described is the revised baseline and the enhanced configuration.
B.G.

N88-14854 Committee on Science, Space and Technology (U.S. House).
THE 1988 NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA) AUTHORIZATION
Washington GPO 1987 1206 p Hearings before the Subcommittee on Space Science and Applications of the Committee on Science, Space and Technology, 100th Congress, 1st Session, No. 35, Vol. 2, 5, 24-25 Feb.; 3, 5, 10-11, 18-19, 31 Mar.; 23 Apr. and 6 May 1987
(GPO-76-600) Avail: Subcommittee on Space Science and Applications

The fiscal year 1988 budget request is examined for the National Aeronautics and Space Administration programs which include: orbital space station; resumption of shuttle flights; expendable launch vehicles (ELVs); research and development; space transportation system; construction; and Advanced Communication Technology Satellite (ACTS).
B.G.

N88-14855*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)/AMERICAN SOCIETY FOR ENGINEERING EDUCATION (ASEE) SUMMER FACULTY FELLOWSHIP PROGRAM, 1987. VOLUME 1 Final Reports
WILLIAM B. JONES, ed. (Texas A&M Univ., College Station.) and STANLEY H. GOLDSTEIN, ed. Nov. 1987 326 p Program held in Houston, Tex., 1987; sponsored by NASA, Johnson Space Center, Houston, Tex. and Texas A/M Univ., College Station
(Contract NGT-44-001-800)
(NASA-CR-172009-VOL-1; NAS 1.26:172009-VOL-1) Avail: NTIS HC A15/MF A01 CSCL 05A

The objective of the NASA/ASEE program were: (1) to further the professional knowledge of qualified engineering and science faculty members; (2) to stimulate an exchange of ideas between participants and NASA; (3) to enrich and refresh the research and teaching activities of participants' institutions; and (4) to contribute to the research objectives of the NASA centers. Each faculty fellow spent 10 weeks at Johnson Space Center engaged in a research project commensurate with his/her interests and background and worked in collaboration with a NASA/JSC colleague. A compilation is presented of the final reports on the research projects done by the fellows during the summer of 1987. This is volume 1 of a 2 volume report.

N88-14874*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)/AMERICAN SOCIETY FOR ENGINEERING EDUCATION (ASEE) SUMMER FACULTY FELLOWSHIP PROGRAM, 1987. VOLUME 2 Final Reports
WILLIAM B. JONES, JR., ed. (Texas A&M Univ., College Station.) and STANLEY H. GOLDSTEIN, ed. Nov. 1987 332 p Program held in Houston, Texas, 1987; sponsored by NASA, Johnson Space Center, Houston and Texas A/M Univ., College Station
(Contract NGT-44-001-800)
(NASA-CR-172009-VOL-2; NAS 1.26:172009-VOL-2) Avail: NTIS HC A15/MF A01 CSCL 05A

The 1987 Johnson Space Center (JCS) National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship program was conducted by Texas A and M University and JSC. The 10-week program was operated under the auspices of ASEE. The basic objectives of the program are: to further the professional knowledge of qualified engineering and science faculty members; to stimulate an exchange of ideas between participants and NASA; to enrich and refresh the research and teaching activities of participants' institutions; and to contribute to the research objective of the NASA Centers. This document is a compilation of the final reports on the research projects done by the faculty fellows during the summer of 1987.

N88-16778# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Earth Observation Programs Dept.
AN OVERVIEW OF THE CURRENT EARTH OBSERVATION PROGRAMS (EUROPE, USA, AND JAPAN)
B. R. K. PFEIFFER *In its* Proceedings of the ESA Workshop on Co-Orbiting Platform Elements (COPE) p 9-12 Sep. 1987 Original contains color illustrations
Avail: NTIS HC A04/MF A01

The ESA Meteosat, ERS-1, and Earthnet programs are outlined, and their follow-ons and solid Earth and Columbus missions are presented. The NASA Upper Atmosphere Research Satellite, the NASA Scatterometer, the TOPEX/POSEIDON program, shuttle-borne Earth observation payloads, airborne programs, and the implementation of a global Earth observation system are introduced. The NOAA GOES satellites and polar orbiting satellites are discussed. Japanese meteorological and polar orbiting satellites are described. ESA

N88-16780# European Space Agency, Paris (France). Space Station and Platforms Directorate.
SPACE STATION OVERVIEW
G. P. HASKELL *In its* Proceedings of the ESA Workshop on Co-Orbiting Platform Elements (COPE) p 17-20 Sep. 1987 Original contains color illustrations
Avail: NTIS HC A04/MF A01

The Core Space Station and the Columbus, man tended free flyer, co-orbiting platform, attached payloads, and Japanese Experiment Module are illustrated. Columbus is mainly devoted to fluid sciences, life sciences, and material sciences, but Earth observation is possible. Free flyers are intended for activities requiring uninterrupted and high quality microgravity exposure. The Japanese module is designed for general scientific and technological studies. ESA

N88-17710*# Norfolk Public Schools, Va. Science and Technology Advanced Research.
THE NORSTAR PROGRAM: SPACE SHUTTLE TO SPACE STATION
RONALD C. FORTUNATO *In* NASA. Goddard Space Flight Center, The 1987 Get Away Special Experimenter's Symposium p 133-140 Feb. 1988
Avail: NTIS HC A08/MF A01 CSCL 22A

The development of G-325, the first high school student-run space flight project, is updated. An overview is presented of a new international program, which involves students from space station countries who will be utilizing Get Away Special technology to cooperatively develop a prototype experiment for controlling a space station research module environment. Author

N88-17713# National Defense Univ., Washington, D. C.
AMERICA PLANS FOR SPACE
1986 201 p
(AD-A187465) Avail: NTIS HC A10/MF A01 CSCL 22A

A report on America's future plans for space exploration contains the following: Pursuing a Balanced Space Program; The Space Defense Initiative; Warfare in Space; The Lunar Laboratory; The Role of Space in Preserving the Peace; Living off the Land-the Use of Resources in Space for Future Civilian Space Operations; The Military Uses of Space; C3I(Command Control Communications and Intelligence); Aspects of Space Technology; Arms Control in Space: Preserving Critical Strategic Space Systems Without Weapons in Space; Space and Arms Control: A Skeptical View; Options for Space Arms Control; Space Arms Control. GRA

N88-17727*# National Academy of Sciences - National Research Council, Washington, D. C. Committee on the Space Station.
REPORT OF THE COMMITTEE ON THE SPACE STATION OF THE NATIONAL RESEARCH COUNCIL Final Report, May - Sep. 1987
Sep. 1987 50 p
(Contract NASW-3511)
(NASA-CR-181602; NAS 1.26:181602; PB88-126073) Avail: Committee on Space Station, National Research Council, 2101 Constitution Avenue N.W., Washington, D.C. 20418 HC free; NTIS MF A01 CSCL 22B

The Space Station Program will be the most ambitious space project the nation has ever undertaken; will require tens of billions of dollars; and will entwine for many years the space program with those of international partners. It must have enduring stable support across administrations, and the support must be generous. The current Space Shuttle is barely adequate for the limited purpose of deploying the Space Station, and it is inadequate to meet broader national needs in space. The Committee recommends in the strongest terms that the Shuttle be upgraded with new improved solid rocket motors, that it be supplemented with expendable launch vehicles, and that a heavy lift launch vehicle be developed for use in the latter half of the 1990s. The Committee strongly recommends that NASA prepare a new Space Station Program cost estimate in conjunction with the Program Requirements Review scheduled for early next year by NASA. The exercise should address the full range of uncertainties in the current Program, some of which are discussed in the report. GRA

N88-17858# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany). Unternehmensgruppe Raumfahrt.
PROJECT MANAGEMENT IN ASTRONAUTICS: FROM SPACELAB TO COLUMBUS [PROJEKT-MANAGEMENT IN DER RAUMFAHRT- VON SPACELAB ZU COLUMBUS]
ANTS KUTZER *In its* Research and Development. Technical-Scientific Publications (1956-1987): Retrospective View and Prospects. Jubilee Edition on the Occasion of the 75th Anniversary of Dipl.-Engr. Dr.-Engr. E.H. Ludwig Boelkow p 257-262 1987 In GERMAN Presented at a conference, Aachen, Fed. Republic of Germany, 29 Jan. 1987
(MBB-URE-943/87) Avail: NTIS HC A14/MF A01

The history of the Spacelab project is depicted. The modular construction, the major Spacelab flight elements, flight hardware, flight configurations, and typical missions are described. Frequently occurring errors, which have to be considered by the management, are discussed. The concept of the European Columbus project is outlined. The industrial and management organization of the project are presented. ESA

N88-19377*# Priem Consultants, Inc., Cleveland, Ohio.
STUDY OF INDUSTRY REQUIREMENTS THAT CAN BE FULFILLED BY COMBUSTION EXPERIMENTATION ABOARD SPACE STATION Final Contractor Report
RICHARD J. PRIEM Mar. 1988 62 p
(Contract NAS3-24105)
(NASA-CR-180854; E-3901; NAS 1.26:180854) Avail: NTIS HC A04/MF A01 CSCL 22A

The purpose of this study is to define the requirements of commercially motivated microgravity combustion experiments and the optimal way for space station to accommodate these requirements. Representatives of commercial organizations, universities and government agencies were contacted. Interest in and needs for microgravity combustion studies are identified for commercial/industrial groups involved in fire safety with terrestrial applications, fire safety with space applications, propulsion and power, industrial burners, or pollution control. From these interests and needs experiments involving: (1) no flow with solid or liquid fuels; (2) homogeneous mixtures of fuel and air; (3) low flow with solid or liquid fuels; (4) low flow with gaseous fuel; (5) high pressure combustion; and (6) special burner systems are described and space station resource requirements for each type of experiment provided. Critical technologies involving the creation of a laboratory environment and methods for combining experimental needs into one experiment in order to obtain effective use of space station are discussed. Diagnostic techniques for monitoring combustion process parameters are identified. Author

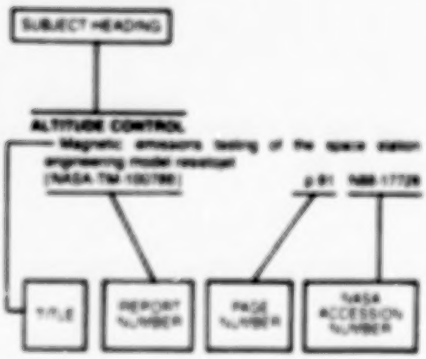
N88-20253*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
RESEARCH AND TECHNOLOGY, 1987 Annual Report

Dec. 1987 143 p
(NASA-TM-100323; NAS 1.15:100323) Avail: NTIS HC A07/MF A01 CSCL 05A

Three broad goals were presented by NASA as a guide to meet the challenges of the future: to advance scientific knowledge of the planet Earth, the solar system, and the universe; to expand human presence beyond the Earth into the solar system; and to strengthen aeronautics research and technology. Near-term and new-generation space transportation and propulsion systems are being analyzed that will assure the nation access to and presence in space. Other key advanced studies include large astronomical observatories, space platforms, scientific and commercial payloads, and systems to enhance operations in Earth orbit. Longer-range studies include systems that would allow humans to explore the Moon and Mars during the next century. Research programs, both to support the many space missions studied or managed by the Center and to advance scientific knowledge in selected areas, involve work in the areas of atmospheric science, earth science, space science (including astrophysics and solar, magnetospheric, and atomic physics), and low-gravity science. Programs and experiment design for flights on the Space Station, free-flying satellites, and the Space Shuttle are being planned. To maintain a leadership position in technology, continued advances in liquid and solid propellant engines, materials and processes; electronic, structural, and thermal investigations; and environmental control are required. Progress during the fiscal year 1987 is discussed.

B.G.

Typical Subject Index Listing



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A

AC GENERATORS
The ac power system testbed
(NASA-CR-175368) p 72 N88-11048
Computer aided modeling and prediction of performance of the modified Lundell class of alternators in space station solar dynamic power systems
(NASA-CR-182538) p 74 N88-19000

ACCELERATION (PHYSICS)
Acceleration measurement and management on a space station
(AF PAPER 87-364) p 50 A88-18249
Materials processing twin experiment
(AIAA PAPER 88-0348) p 183 A88-22200

ACCELERATORS
Ram accelerator direct launch system for space cargo
(AF PAPER 87-211) p 182 A88-15944

ACCESS CONTROL
Access control for a safety critical distributed system interface unit
(AIAA PAPER 87-3083) p 100 A88-26211

ACEE PROGRAM
Department of Housing and Urban Development-Independent Agencies Appropriations for fiscal year 1988. Friday, 10 April 1987. National Aeronautics and Space Administration
p 166 N88-12425

ACOUSTIC EXCITATION
ENVIRONET database on vibroacoustics
(AIAA PAPER 88-0010A) p 95 A88-22011

ACTIVE CONTROL
Structural design and decoupled control — of large space structures
(AF PAPER 87-316) p 46 A88-18018
ITDS - A program for interactive design and analysis of advanced active thermal control systems
(SAE PAPER 871401) p 34 A88-21380
Space Station Active Thermal Control System modeling
(AIAA PAPER 88-0472) p 36 A88-22340
Root locus method for active control of flexible systems p 53 A88-24508
Optimization of actively controlled structures using goal programming techniques p 53 A88-25197
Active vibration control on the OSU flexible beam p 15 A88-27357
Active modification of wave reflection and transmission in flexible structures p 16 A88-27395
Identification and control of flexible structures p 54 A88-27768
Control augmented structural synthesis
(AIAA PAPER 88-1014) p 55 A88-28043
Dynamics and control of a planar truss actuator p 55 A88-31164
Active vibration control in microgravity environment p 55 A88-31165
Experimental studies of active members in control of large space structures
(AIAA PAPER 88-2207) p 94 A88-32178
Low authority threshold control for large flexible structures
(AIAA PAPER 88-2210) p 22 A88-32226
Control for energy dissipation in structures
(AIAA PAPER 88-2272) p 22 A88-32228
Modeling and control of large flexible vehicles in the atmosphere and space
(AD-A185368) p 27 N88-11027
Cartesian path control of a two-degree-of-freedom robot manipulator
(NASA-CR-182331) p 60 N88-13938
Active control of flexural vibrations in beams p 50 N88-14866
Sensitivity of active vibration control to structural changes and model reduction p 35 N88-17683

ACTS
Communication satellite technology trends p 76 N88-13088

ACTUATORS
Application of magnetic bearings to high torque satellite attitude control wheels p 67 A88-11908
Development of the Mast Flight System linear dc motor mortar actuator
(AAS PAPER 87-021) p 13 A88-10990
Sensor and actuator selection for optimal closed-loop performance in the presence of correlated noise p 54 A88-27397

ADA (PROGRAMMING LANGUAGE)
AIAA Computers in Aerospace Conference, 6th, Wakefield, MA, Oct. 7-9, 1987, Technical Papers p 91 A88-12526
Translation and execution of distributed Ada programs - is it still Ada? p 7 A88-21643
Can space station software be specified through Ada? p 9 N88-19602

ADAPTIVE CONTROL
An integrated approach to space station power system autonomous control p 67 A88-11853
Application of advanced automation techniques in the Space Station electrical power system p 75 A88-11855
Control of gripper position of a compliant link using strain gauge measurements p 48 A88-14005
Application of adaptive observers to the control of flexible spacecraft p 50 A88-14096
Proposal of adaptively controlled transmitting array for microwave power transmission in space p 53 A88-25854
Adaptive control of Large Space Structure (LSS)
(ISAS-R-621) p 58 N88-11740
Dynamics, control and sensor issues pertinent to robotic hands for the EVA retriever system p 60 N88-14078
Solid modeling for the manipulative robot arm (power) and adaptive vision control for space station missions p 60 N88-16408

ADAPTIVE OPTICS
Wavefront error sensing
(NASA-CR-181554) p 78 N88-12030

ADSORPTION
Use of hydrophilic polymer coatings for control of electroosmosis and protein adsorption p 119 N88-15620

ADVANCED TECHNOLOGY LABORATORY
Conceptual design of the advanced technology platform
(AF PAPER 87-02) p 109 A88-15402

AEROASSIST
Optimal trajectories for aeroassisted noncoplanar orbital transfer. I - LEO-to-LEO transfer
(AF PAPER 87-328) p 49 A88-16029
Aeroassisted vehicle design studies for a manned Mars mission
(AF PAPER 87-433) p 50 A88-16093
Aeroassisted orbital transfer vehicle guidance performance in the presence of density dispersions
(AIAA PAPER 88-0302) p 100 A88-22217
Effect of rotating earth for analysis of aeroassisted orbital transfer vehicles p 3 A88-26257
Aeroassisted vehicle design studies for a manned Mars mission
(NASA-TM-100531) p 59 N88-11703
Aeroassisted manned transfer vehicle (TAV) for advanced Mars Transportation (NASA/USRA 1987 Senior Design Project
(NASA-CR-181678) p 108 N88-11736
An analysis of the effect of aeroassist maneuvers on orbital transfer vehicle performance
(NASA-TM-89117) p 150 N88-14114
Aeroassisted orbit transfer vehicle trajectory analysis
(NASA-TM-89139) p 62 N88-19575

AEROBRAKING
Aeroassisted vehicle design studies for a manned Mars mission
(AF PAPER 87-433) p 50 A88-16093
Aeroassisted vehicle design studies for a manned Mars mission
(NASA-TM-100531) p 59 N88-11703
Aeroassisted manned transfer vehicle (TAV) for advanced Mars Transportation (NASA/USRA 1987 Senior Design Project
(NASA-CR-181678) p 108 N88-11736

AERODYNAMIC CHARACTERISTICS
Tether satellite potential for rarefied gas aerodynamic research
(AIAA PAPER 88-0667) p 114 A88-22513
Computational methods for problems in aerodynamics and large space structure using parallel and vector architectures
(AD-A185401) p 27 N88-13294

AERODYNAMIC DRAG
Active vibration control in microgravity environment p 55 A88-31165

AERODYNAMIC FORCES
Computational methods for problems in aerodynamics and large space structure using parallel and vector architectures
(AD-A185401) p 27 N88-13294

AEROELASTICITY
On control of tethered satellite systems p 110 A88-16294

AERONAUTICAL ENGINEERING
Research and technology, 1987
(NASA-TM-100323) p 187 N88-20253

AEROSOLS
Airborne particulate matter in spacecraft
(NASA-CP-2499) p 157 N88-14023
Atmospheric science p 5 N88-15357

AEROSPACE ENGINEERING
National Space Engineering Symposium, 2nd, Sydney, Australia, Mar. 25-27, 1986, Preprints, Volumes 1 & 2 p 139 A88-15476
Investigation of design concepts for large space structures to support military applications
(AD-A186098) p 20 N88-15000

AEROSPACE ENVIRONMENTS
Experiments in advanced control concepts for space robotics: An overview of the Stanford Aerospace Robotics Laboratory
(AAS PAPER 87-044) p 63 A88-18089

169

Technology demonstrator program for Space Station Environmental Control Life Support System
[SAE PAPER 871456] p 41 A88-21115
Large space systems: environmental entanglements
[AIAA PAPER 88-0360] p 14 A88-22399
Applications of tethered satellites to some problems of terrestrial physics
[AIAA PAPER 88-0689] p 114 A88-22516
The combined release and radiation effects satellite, a joint NASA/DOD program p 131 N88-10851
Space Environment Technology — conference
[ISBN-2-85428-170-5] p 132 N88-11702
Low Earth orbit environmental effects on the space station photovoltaic power generation systems
[NASA-TM-100236] p 73 N88-12429
Airborne particulate matter in spacecraft
[NASA-CP-2499] p 157 N88-14623
Space environmental effects on polymeric materials
[NASA-CR-182418] p 97 N88-15082
Exobiology and life science p 119 N88-15358
Space environmental effects on polymeric materials
[NASA-CR-182454] p 97 N88-15879
Space station integrated wall damage and penetration damage control. Task 5: Space debris measurement, mapping and characterization system
[NASA-CR-179391] p 30 N88-17088
Oxidation and protection of fiberglass-epoxy composite masts for photovoltaic arrays in the low Earth orbital environment
[NASA-TM-100839] p 97 N88-19734
Microgravity and Materials Processing Facility study (MMPF): Requirements and Analyses of Commercial Operations (RACO) preliminary data release
[NASA-CR-179309] p 104 N88-19742
Study of industry requirements that can be fulfilled by combustion experimentation aboard space station
[NASA-CR-180854] p 167 N88-19377

AEROSPACE INDUSTRY

Planning framework for high-technology space flight (OHR) p 142 A88-23516

AEROSPACE MEDICINE

Results of medical investigations conducted aboard the 'Salyut-6'-'Soyuz' orbital research complex — Russian book p 135 A88-15650
Biomedical payload of the French-Soviet long duration flight
[IAF PAPER 87-541] p 152 A88-16159
Psychiatric components of a Health Maintenance Facility (HMF) on Space Station p 153 A88-21864
Medical effects of iodine disinfection products in spacecraft water
[SAE PAPER 871490] p 154 A88-21144
The role of preventive medicine in the future of USA space life sciences p 155 A88-29104
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment p 145 N88-12917
JPRS report: Science and technology. USSR: Space
[JPRS-USP-87-006] p 146 N88-16063
Full scale architectural simulation techniques for space stations p 10 N88-19867
Medilab: A project of a medical laboratory in space p 103 N88-19946

AEROSPACE PLANES

Japan takes charge p 143 A88-27952

AEROSPACE SAFETY

Progress towards autonomous, intelligent systems
[IAF PAPER 87-31] p 83 A88-15823
A smoke removal unit
[SAE PAPER 871449] p 153 A88-21159
Debris hazard poses future threat p 131 A88-24846
Safety philosophy, policy, and requirements for manned spaceflight. Volume 1: Executive summary
[HEG-0886/1036-VOL-1] p 157 N88-15826

AEROSPACE SCIENCES

Science on the Space Station: The opportunity and the challenge - A NASA view
[IAF PAPER 87-02] p 98 A88-15903
Science on Space Station p 2 A88-21388
Space science with Columbus p 141 A88-21587
Proceedings of the Fourth Annual US Space Development Conference p 163 A88-23990

AEROSPACE SYSTEMS

Strengthening graphite-epoxy composites p 95 A88-21554
Autonomy, automation, and systems p 85 A88-21640
Maximum entropy/optimal projection design synthesis for decentralized control of large space structures
[AD-A186059] p 29 N88-15903
KBS V and V as related to automation of space station subsystems: Rationale for a KBS lifecycle p 9 N88-16375

AEROSPACE TECHNOLOGY TRANSFER

Technology - The basis for the past, the key to the future
[IAF PAPER 87-47] p 161 A88-15833
A 50 year scenario for the utilization of space to improve the quality of life on earth p 164 A88-21656

AEROSPACE VEHICLES

Dynamic characterization of structures by pulse probing and deconvolution
[AIAA PAPER 88-2230] p 21 A88-32183
Computational methods for problems in aerodynamics and large space structure using parallel and vector architectures
[AD-A185401] p 27 N88-13284

AEROTHERMODYNAMICS

Thermal response of integral multicomponent composites to a high-energy aerothermodynamic heating environment with surface temperatures to 1930 K p 92 A88-12591
Tethered space system - A new facility for experimental rarefied gas dynamics p 111 A88-16858
Low density aerothermodynamics studies performed by means of the tethered satellite system p 111 A88-16859
Downward-deployed tethered platforms for high enthalpy aerothermodynamic research
[AIAA PAPER 88-2686] p 114 A88-22514
Aerothermodynamics: A key to new aerospace transport systems
[DGLR PAPER 87-077] p 4 A88-32477

AGGREGATES

Planetary science p 5 N88-15356

AIR LOCKS

Fusion subsystem responsibilities on Columbus 9 phase studies p 141 A88-21581

AIR PURIFICATION

The Space Station air revitalization subsystem design concept
[SAE PAPER 871448] p 40 A88-21138
Airborne particulate matter in spacecraft
[NASA-CP-2499] p 157 N88-14623

AIR QUALITY

Airborne particulate matter in spacecraft
[NASA-CP-2499] p 157 N88-14623

AIRBORNE/SPACEBORNE COMPUTERS

AIAA Computers in Aerospace Conference, 6th, Wakefield, MA, Oct. 7-9, 1987, Technical Papers p 81 A88-12526
Autonomous spacecraft operations - Problems and solutions
[AIAA PAPER 87-2950] p 91 A88-12571
Spaceborne optical disk controller development p 90 A88-12705
The use of transputers in processing telemetry data p 90 A88-15393
Damning the data stream from space p 38 A88-15860
Translation and execution of distributed Ada programs - Is it still Ada? p 7 A88-21643
Evolution of data management systems from Spacelab to Columbus
[MBB-UR-E 968-87] p 99 A88-23981
Access control for a safety critical distributed system interface set
[AIAA PAPER 87-3063] p 100 A88-26011
Study of fault tolerant techniques for satellite data handling
[PTT/REP/0001/0AAB] p 101 N88-13860
The feasibility of using TAE as the UI, for the space station and for other internal NASA tasks and projects p 9 N88-15618
Intelligent man/machine interfaces on the space station p 90 N88-16416
Prototype space station automation system delivered and demonstrated at NASA p 45 N88-16442
Applications of expert systems for satellite autonomy p 90 N88-16443

AIRCRAFT CONSTRUCTION MATERIALS

Advanced materials technology '87; Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr. 6-9, 1987 p 1 A88-13129

AIRCRAFT STRUCTURES

Optimum design of structures with multiple constraints p 14 A88-29042

AIRLOCK MODULES

On-orbit servicing enhancements with Crewlock EVA operations from the Spacehab module
[SAE PAPER 871498] p 124 A88-21148

ALGAE

The feasibility of Chlorella as the exchanger of CO2 for O2 and the food resources in the Space Station p 43 A88-29136
Sunlight supply and gas exchange systems in microalgae bioreactor p 44 N88-15258

ALGORITHMS

AUTOPLAN - A PC-based automated mission planning tool p 7 A88-25486
Some experiences with the Eigensystem Realization Algorithm p 17 A88-29815
Now feedback design methodologies for large space structures: A multi-criterion optimization approach p 59 N88-12535
Vision technology/algorithms for space robotics applications p 90 N88-17267
Formulation methods of rigid multibody systems for large space structures and some results of computer simulation
[NAL TR-942] p 30 N88-17730

ALLOCATIONS

An allotment planning concept and related computer software for planning the fixed satellite service at the 1988 space WARC
[NASA-TM-100244] p 165 N88-11944

ALTITUDE CONTROL

Magnetic emissions testing of the space station engineering model reaction
[NASA-TM-100788] p 91 N88-17726

ALUMINUM

Chromic acid anodizing of aluminum foil
[NASA-CR-179417] p 97 N88-15077

ALUMINUM GALLIUM ARSENIDES

An amplitude modulated laser system for distance and displacement measurement p 47 A88-12913

AMBULANCES

Orbit design for a space ambulance vehicle p 149 A88-15313

AMINES

Stability of IRA-45 solid amine resin as a function of carbon dioxide absorption and steam desorption cycling
[SAE PAPER 871452] p 40 A88-21112

AMMONIA

Pumped two-phase ammonia thermal bus test bed
[SAE PAPER 871442] p 34 A88-21104

AMPLITUDE MODULATION

An amplitude modulated laser system for distance and displacement measurement p 47 A88-12913

ANGULAR ACCELERATION

Artificial gravity - A countermeasure for zero gravity
[IAF PAPER 87-533] p 105 A88-16156

ANGULAR DISTRIBUTION

A measurement of the angular distribution of 5-eV atomic oxygen scattered off a solid surface in earth orbit p 130 A88-15866

ANGULAR MOMENTUM

Application of magnetic bearings to high-torque, satellite attitude control wheels p 47 A88-11938
Angular momentum management for LEO platforms
[IAF PAPER 87-349] p 49 A88-16039
Space Station attitude control momentum requirements
[AIAA PAPER 88-0672] p 51 A88-22502

ANIMALS

Space station accommodations for life sciences research facilities. Phase 1: Conceptual design and programmatics studies for Missions SAAX0307, SAAX0302 and the transition from SAAX0307 to SAAX0302. Volume 2: Study results
[NASA-CR-179244] p 104 N88-15828
Space station accommodations for life sciences research facilities. Phase A conceptual design and programmatics studies for Missions SAAX0307, SAAX0302 and the transition from SAAX0307 to SAAX0302. Volume 1: Executive summary
[NASA-CR-179267] p 104 N88-19571
Animal research on the Space Station p 159 N88-19964

ANISOTROPIC MEDIA

Recent advances in dynamics of composite structures p 19 A88-31427

ANODIZING

Chromic acid anodizing of aluminum foil
[NASA-CR-179417] p 97 N88-15077

ANTENNA ARRAYS

Compensation of reactor antenna surface distortion using an array feed
[NASA-TM-100286] p 77 N88-16835

ANTENNA COMPONENTS

Studies of the structural dynamic behavior of satellite antenna system
[AD-A185526] p 28 N88-14121

ANTENNA DESIGN

The use of advanced materials in space structure applications
[IAF PAPER 87-305] p 94 A88-16036
Large inflatable, space-rigidized antenna reflectors - Land mobile services development
[IAF PAPER 87-315] p 12 A88-16013
Research and development of the tension truss antenna
[IAF PAPER 87-317] p 12 A88-16014

Deployable umbrella reflector antennas — Russian book p 143 A89-27743
Mechanical properties characterization of composite sandwich materials intended for space antenna applications
[NASA-TM-88893] p 25 N89-10121
Studies of the structural dynamic behavior of satellite antenna system
[AD-A185526] p 29 N89-14121
National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 2
[NASA-CR-172009-VOL-2] p 166 N89-14874
Automatic antenna switching design for Extra Vehicular Activity (EVA) communication system p 77 N89-14883
Multisurface control mechanism for a deployable antenna. Far Infrared and Submillimeter Space Telescope (FIRST) technology study
[RP-FA-D003] p 120 N89-16867

ANTENNA FEEDS
Compensation of reflector antenna surface distortion using an array feed
[NASA-TM-100296] p 77 N89-16835

ANTENNA RADIATION PATTERNS
Radiation characteristics of offset radial rib reflector antennas p 34 A89-17566
A near field test system for very large antennas p 13 A89-17589

ANTIBIOTICS
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment p 145 N89-12917
Antibiotic activity in space: results and hypotheses p 159 N89-16952

ANTIGENS
A solid phase enzyme-linked immunosorbent assay for the antigenic detection of Legionella pneumophila (serogroup 1): A component for the space station diagnostic capability p 157 N89-14868

ANTIMISSILE DEFENSE
Investigation of design concepts for large space structures to support military applications
[AD-A186098] p 29 N89-15093

ANTISEPTICS
Review of water disinfection techniques
[SAE PAPER 871398] p 42 A89-21142
Consequences of bacterial resistance to disinfection by iodine in potable water
[SAE PAPER 871489] p 42 A89-21143
Medical effects of iodine disinfection products in spacecraft water
[SAE PAPER 871490] p 154 A89-21144
Toxicological aspects of water recycle and disinfection
[SAE PAPER 871491] p 42 A89-21145

APPENDAGES
An experimental study on flexible spacecraft three-axis attitude control p 53 A89-26256

APPLICATIONS PROGRAMS (COMPUTERS)
Recent advances in structural dynamics of large space structures
[NASA-TM-100513] p 26 N89-10867
Pinhole occulter experiment
[NASA-CR-179206] p 116 N89-11481
Stochastic model of the NASA/MSFC ground facility for large space structures with uncertain parameters. The maximum entropy approach
[NASA-CR-181489] p 27 N89-12343

APPROACH CONTROL
Space vehicle approach velocity judgments under simulated visual space conditions
[NASA-TM-89437] p 158 N89-19094

APPROPRIATIONS
The 1988 National Aeronautics and Space Administration (NASA) authorization
[GPO-76-600] p 166 N89-14854

APPROXIMATION
Bit-N approximation - A system simplification method p 54 A89-27402

ARCHITECTURE
Maximum entropy/optimal projection design synthesis for decentralized control of large space structures
[AD-A186358] p 29 N89-15093
Space station architectural elements model study
[REPT-31799] p 10 N89-19885

ARCHITECTURE (COMPUTERS)
Use of a distributed microprocessor network for control of the Space Station electrical power system p 67 A89-11858
The use of transputers in processing telemetry data p 98 A89-15303
Status of the Space Station water reclamation and management subsystem design concept
[SAE PAPER 871510] p 42 A89-21156
System architecture for telerobotic servicing and assembly tasks p 85 A89-21640
Computing architecture for telerobots in earth orbit p 99 A89-21650
Applying technology to systems; Aerospace Computer Security Conference, 3rd, Orlando, FL, Dec. 7-11, 1987, Technical Papers p 8 A89-26259
National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 2
[NASA-CR-172009-VOL-2] p 166 N89-14874
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems
[NASA-TM-89705] p 88 N89-15497
Knowledge-based simulation p 102 N89-19404

ARGON PLASMA
Plasma contactors for use with electrodynamic tethers for power generation
[IAF PAPER 87-251] p 69 A89-15975

ARIANE LAUNCH VEHICLE
Evolution towards an autonomous European manned space infrastructure
[IAF PAPER 87-67] p 136 A89-15946
Challenge '95 - The Ariane 5 Development Programme
[IAF PAPER 87-185] p 137 A89-15926
Orbital systems p 143 A89-26170
ESA Bulletin No. 25
[ISSN-0376-4265] p 146 N89-16767

ARIES SOUNDING ROCKET
Space Station logistic support by Aries
[IAF PAPER 87-222] p 137 A89-15950

ARRAYS
Performance characteristics of a combination solar photovoltaic heat engine energy converter p 65 A89-11913

ARTIFICIAL GRAVITY
Motion perturbations of a dumbbell in a central Newtonian force field p 47 A89-11235
Artificial gravity - A countermeasure for zero gravity
[IAF PAPER 87-533] p 105 A89-16156
Providing artificial gravity - Physiologic limitations to rotating habitats
[IAF PAPER 87-545] p 152 A89-16163
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 4: Supportability analysis of the 1.8m centrifuge p 6 N89-19401
Analyses of a rotating advanced technology space station for the year 2025
[NASA-CR-178345] p 107 N89-19580

ARTIFICIAL INTELLIGENCE
Applications for power control within a Space Station module p 67 A89-11934
Automated space power distribution and load management p 67 A89-11960
Automated testing and integration of heterogeneous systems — for Space Station power management p 20 A89-11974
Autonomous spacecraft operations - Problems and solutions
[AIAA PAPER 87-2950] p 91 A89-12571
Building intelligent systems - Artificial intelligence research at NASA Ames Research Center p 92 A89-15390
Progress towards autonomous, intelligent systems
[IAF PAPER 87-31] p 93 A89-15823
Automatic planning research applied to orbital construction p 124 A89-21627
The distributed AI system for the dynamic allocation and management of power (DAISY-DAMP) testbed p 84 A89-21636
The NASA telerobot technology demonstrator p 95 A89-21651
Theoretical considerations in designing operator interfaces for automated systems p 95 A89-21656
Intelligent systems and robotics for an evolutionary Space Station p 98 A89-24239
Space Station Mission Planning System (MPS) development study. Volume 1: Executive summary
[NASA-CR-179202] p 4 N89-10947
Space Station Mission Planning System (MPS) development study. Volume 2
[NASA-CR-179206] p 4 N89-10948
Space Station Mission Planning Study (MPS) development study. Volume 3: Software development plan
[NASA-CR-179203] p 4 N89-10949
Potential applications of expert systems and operations research to space station logistics functions
[NASA-CR-180473] p 87 N89-12342
Dynamics, control and sensor issues pertinent to robotic hands for the EVA retriever system p 88 N89-14875
Expert system study for spacecraft management
[TL-2639-03-1] p 101 N89-19364
MTX: An AI tool for model-based reasoning p 9 N89-19372
KBS V and V as related to automation of space station subsystems. Rationale for a KBS lifecycle p 9 N89-19375
Monitoring of space station: life support systems with miniature mass spectrometry and artificial intelligence p 45 N89-19376
Knowledge-based simulation p 102 N89-19404
Planning and scheduling for robotic assembly p 90 N89-19416
Intelligent man/machine interfaces on the space station p 90 N89-19418
An AI approach for scheduling space-station payloads at Kennedy Space Center p 90 N89-19425
A human performance modeling approach to intelligent decision support systems p 90 N89-17242
Robotic intelligence issues for space manipulator monitoring, control programming p 92 N89-19504
Mobile robot activity model for autonomous free flying platforms p 92 N89-19507

ARTIFICIAL SATELLITES
The combined release and radiation effects satellite, a joint NASA/DOD program p 131 N89-10851
SAMSS: An in-progress review of the Spacecraft Assembly, Maintenance, and Servicing Study p 127 N89-15930
Applications of expert systems for satellite autonomy p 90 N89-19443
Formulation methods of rigid multibody systems for large space structures and some results of computer simulation
[NAL TR-942] p 30 N89-17791
Customer concerns regarding satellite servicing p 129 N89-19503

ASSEMBLING
Space Assembly, Maintenance, and Servicing Study (SAMSS) p 125 N89-10089
Space station assembly/servicing capabilities p 125 N89-10100
Structural Assembly Demonstration Experiment (SADE)
[NASA-CR-178095] p 26 N89-10868
Experimental assembly of structures in EVA: Hardware morphology and development issues p 26 N89-10872
Access flight hardware design and development p 26 N89-10873
Marshall Space Flight Center's role in EASE/ACCESS mission management p 27 N89-10875
Research and development at the Marshall Space Flight Center Neutral Buoyancy Simulator p 5 N89-10879
A synopsis of the EVA training conducted on EASE/ACCESS for STS-61-B p 126 N89-10879
Results of the ACCESS experiment p 27 N89-10880
Overview of crew member energy expenditure during Shuttle Flight 61-B EASE/ACCESS task performance p 156 N89-10882
Design and assembly sequence analyses of option 3 for CETI reference space station
[NASA-TM-100503] p 126 N89-13360
RETE experiment Assembly, Integration, and Verification (AIV) activities
[IFSI-87-6] p 117 N89-13380
Planning and scheduling for robotic assembly p 90 N89-19416

ASSEMBLY
Fabrication and assembly of an advanced composite Space Station tetrahedron cell p 11 A89-13189

ASTRODYNAMICS
Dynamics and control of the tethered satellite system in the presence of offsets
[IAF PAPER 87-316] p 109 A89-16014
The dynamics and control of large space structures after the onset of thermal shock
[IAF PAPER 87-351] p 49 A89-16041
Mathematical models of flexible spacecraft dynamics - A survey of order reduction approaches p 13 A89-16293
Dynamics and control of the Tethered Satellite System in the presence of offsets p 110 A89-20006
Tether Dynamics Simulation Workshop summary
[AIAA PAPER 88-0531] p 113 A89-22397
Tether technology - Conference summary
[AIAA PAPER 88-0530] p 113 A89-22398
Attitude control of a three rotor gyrostat in the presence of uncertainty p 52 A89-22900

ASTROMETRY
An operations concept for the Space Station based Astrometric Telescope Facility
[AIAA PAPER 88-0447] p 113 A89-22333
Performance considerations for the astrometric telescope facility on the phase 1 space station
[NASA-TM-100040] p 45 N89-14908

ASTRONAUT PERFORMANCE
Small groups in orbit - Group interaction and crew performance on Space Station p 151 A89-15348
Crew productivity issues in long-duration space flight [AIAA PAPER 88-0404] p 154 A88-22330
The Soviet cosmonaut team, 1978-1987 p 144 A88-30195
Results of the ACCESS experiment p 27 N88-10880
EASE (Experimental Assembly of Structures in EVA) overview of selected results p 126 N88-10881
Overview of crew member energy expenditure during Shuttle Flight 61-B EASE/ACCESS task performance p 156 N88-10882
Implications of shiftwork in space for human physiology experiments p 129 N88-19942

ASTRONAUT TRAINING
Onboard training for the Space Station [AIAA PAPER 88-0445] p 154 A88-22331
A synopsis of the EVA training conducted on EASE/ACCESS for STS-61-B p 126 N88-10879

ASTRONAUTICS
Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings p 161 A89-15276
Space near and far -- Russian book p 142 A88-27734

ASTRONAUTS
Radiation problems with the Space Station scenario and the necessary surveillance for artronauts [IAF PAPER 87-542] p 129 A88-16160

ASTRONOMICAL SATELLITES
An operations concept for the Space Station based Astrometric Telescope Facility [AIAA PAPER 88-0447] p 113 A88-22333

ASTRONOMY
Research and technology, 1987 [NASA-TM-100323] p 167 N88-20253

ASTROPHYSICS
USSR report: Space [JPRS-USP-87-003] p 144 N88-10950
X-ray astronomy instruments to operate on Mir station p 144 N88-10952
Research and technology, 1987 [NASA-TM-100323] p 167 N88-20253

ASYMMETRY
The impact of asymmetric physical properties on large space structures [AIAA PAPER 88-2486] p 19 A88-21595

ATMOSPHERIC CHEMISTRY
The combined release and radiation effects satellite, a joint NASA/DOD program p 131 N88-10851

ATMOSPHERIC COMPOSITION
Spacecraft Fire Safety [NASA-CP-2476] p 150 N88-12520
Fire-related medical science p 156 N88-12525
Spacecraft material flammability testing and configurations p 96 N88-12529

ATMOSPHERIC DENSITY
Aerossisted orbital transfer vehicle guidance performance in the presence of density dispersions [AIAA PAPER 88-0302] p 150 A88-22017

ATMOSPHERIC HEATING
Self-shadowing effects on the thermal-structural response of orbiting trusses p 52 A88-11734

ATMOSPHERIC MODELS
True energy atmospheric simulator for low earth orbit spacies [AIAA PAPER 88-0727] p 3 A88-22549
Analysis of geophysical data bases and models for spacecraft interactions [AD-A184809] p 100 N88-13375

ATMOSPHERIC OPTICS
Stratospheric luminescence observed from the Salyut-7 station p 144 A88-30076

ATMOSPHERIC PHYSICS
Analysis of geophysical data bases and models for spacecraft interactions [AD-A184809] p 100 N88-13375

ATMOSPHERIC SOUNDING
SAFIRE - A novel high resolution cooled spectrometer for atmospheric research [IAF PAPER 87-137] p 109 A88-15884
Tether satellite potential for rarefied gas aerodynamic research [AIAA PAPER 88-0667] p 114 A88-22510

ATMOSPHERIC TEMPERATURE
Reconstruction of the vertical atmospheric temperature profile on the basis of refraction measurements from the Salyut-7 orbital station p 131 A88-23939

ATOMIC BEAMS
High intensity 5 eV O atom exposure facility for material degradation studies p 96 N88-10847

ATOMIC PHYSICS
Research and technology, 1987 [NASA-TM-100323] p 167 N88-20253

ATROPHY
Bones and stones in space - Integrating the medical and scientific questions [SAE PAPER 871465] p 153 A89-21123

ATTITUDE (INCLINATION)
The passive attitude motion of the orbital stations Salyut-6 and Salyut-7 [IAF PAPER 87-355] p 49 A88-16345

ATTITUDE CONTROL
Feedback control for attitude control system of the elastic vehicle p 48 A88-14396
Application of adaptive observers to the control of flexible spacecraft p 50 A88-16296
Space Station attitude control momentum requirements [AIAA PAPER 88-0672] p 51 A88-22502
Flexible spacecraft maneuver - Inverse attitude control and modal stabilization p 53 A88-24281
Dynamics and control characteristics of a reference Space Station configuration [AIAA PAPER 88-2495] p 55 A88-31304
Attitude Control Working Group report p 57 N88-10099
Predictive momentum management for a space station measurement and computation requirements [NASA-CR-172026] p 58 N88-10968
Development of a coupled expert system for the spacecraft attitude control problem p 61 N88-17223

ATTITUDE GYROS
Development experience of the attitude control system using single-axis control moment gyros for long-term orbiting space stations [IAF PAPER 87-04] p 46 A88-15804

ATTITUDE STABILITY
Stability of the steady motions of an electromagnetic tether system in orbit p 107 A89-11234
Motion perturbations of a dumbbell in a central Newtonian force field p 47 A89-11235

AURORAS
AURIC: A proposal for flying auroral imaging observatory on the Polar Platform in the Space Station/Columbus program p 119 N88-16268

AUTOMATIC CONTROL
An integrated approach to space station power system autonomous control p 67 A88-11853
Application of advanced automation techniques in the Space Station electrical power system p 75 A88-11855
LERC power system autonomy program 1990 demonstration p 67 A88-11861
Automated load management for spacecraft power systems p 67 A88-11863
Automatic control in space 1985 p 50 A88-16276
An innovative overview method to simulate orbital EVA work - Applications to PLSS automatic controls [SAE PAPER 871475] p 154 A89-21120
Development of an automated checkout, service, and maintenance system for an EVAS Space Station [SAE PAPER 871497] p 129 A89-21149
Automated Space Station procedure execution [AIAA PAPER 88-0443] p 99 A88-22329
Synthesis of the flexible structures of complex systems p 15 A88-27148
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems [NASA-TM-80705] p 88 N88-15497
Advancing automation and robotics technology for the space station and for the US economy. Submitted to the United States Congress October 1, 1987 [NASA-TM-100777] p 88 N88-15810
Advancing automation and robotics technology for the space station and for the US economy. Submitted to the United States Congress May 15, 1987 [NASA-TM-89811] p 89 N88-15817
Advancing automation and robotics technology for the space station and for the US economy. Submitted to the United States Congress October 1, 1986 [NASA-TM-88190] p 89 N88-15818
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems p 89 N88-16073
KBS V and V as related to automation of space station subsystems. Rationale for a KBS lifecycle p 9 N88-16075
Artificial intelligence and space power systems automation p 90 N88-16381
Prototype space station automation system delivered and demonstrated at NASA p 45 N88-16442

AUTOMATIC FLIGHT CONTROL
Expert system applications in spacecraft subsystem controllers p 90 N88-17254

AUTOMATIC TEST EQUIPMENT
Automated testing and integration of heterogeneous systems -- for Space Station power management p 33 A89-11874

AUTOMATION
A concept for standard load carrier automation p 67 A88-11857
A systems engineering approach to automated failure cause diagnosis in space power systems p 68 A89-11870
Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986 [SPIE-729] p 94 A89-21601
Use of automation and robotics for the Space Station p 94 A89-21632
Automatic planning research applied to orbital construction p 124 A89-21407
NASA Systems Autonomy Demonstration Program - A step toward Space Station automation p 94 A89-21639
Autonomy, automation, and systems p 95 A89-21640
Theoretical considerations in designing operator interfaces for automated systems p 95 A89-21656
Video-based satellite attitude determination p 51 A88-21657
Information prioritization for control and automation of space operations p 96 A89-27355
Technology requirements for teleoperic satellite servicing in space p 93 N88-19536

AUTONOMY
Autonomous spacecraft operations - Problems and solutions [AIAA PAPER 87-2850] p 91 A88-12571
NASA Systems Autonomy Demonstration Program - A step toward Space Station automation p 94 A89-21639
Autonomy, automation, and systems p 95 A89-21640
Autonomous management of the Space Station electric energy system p 71 A89-21641
Expert system study for spacecraft management (TL-2699-(SS-1)) p 101 N88-15004

AUXILIARY PROPULSION
Component data base for space station reentrant auxiliary propulsion [NASA-CR-180834] p 91 N88-17731

AXIAL LOADS
Passive damping for space truss structures [AIAA PAPER 88-2469] p 24 A88-32390

B

BACTERIA
Consequences of bacterial resistance to disinfection by ozone in potable water [SAE PAPER 871469] p 42 A89-21143
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment p 145 N88-12917
Antibiotic activity in space, results and hypothesis p 159 N88-19952

BACTERIAL DISEASES
A solid phase enzyme-linked immunosorbent assay for the antigenic detection of Legionella pneumophila (serogroup 1) & complement for the space station diagnostic capability p 157 N88-14868

BACTERIOLOGY
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment p 145 N88-12917

BAFFLES
Slosh dynamics in a toroidal tank -- for orbit transfer vehicle cryogenic propellant storage p 78 A88-27588

BALLISTICS
Efficient spacecraft formationkeeping with consideration of ballistic coefficient control [AIAA PAPER 88-0375] p [illegible] A88-22077

BALLISTOCARDIOGRAPHY
Ballistocardiography in weightlessness research p 46 N88-19090

BEAM INJECTION
The effect of photoelectrons on beam-satellite potential differences during electron beam ejection [AD-A190390] p 75 A89-20356

BEAMS (SUPPORTS)
Verification of large beam-type space structures p 14 A88-19607
Active vibration control on the CSU flexible beam p 15 A88-27357
Vibration control of truss beam structures using axial force actuators [AIAA PAPER 88-2273] p 22 A88-32209
Optimal control of large space structures via generalized inverse matrix [NASA-CR-180356] p 59 N88-13907
Robust controller design for flexible structures [AD-A197217] p 30 N88-19559

172

BENDING MOMENTS
Finite-element model for the thermoelastic analysis of large composite space structures p 14 A89-19632
Experimental component mode synthesis of structures with sloppy joints
[AIAA PAPER 89-1311] p 24 A89-32339
BIBLIOGRAPHIES
Space near and far -- Russian book
p 143 A89-27734
Spacecraft fire detection and extinguishment: A bibliography
[NASA-CR-182880] p 158 N89-19012
BIOASTRONAUTICS
Medical aspects of orbital spaceflight and their implications for manufacturing in space
p 36 A89-13162
Results of medical investigations conducted aboard the 'Salyut-6 - Soyuz' orbital research complex -- Russian book
p 135 A89-15650
Man in space flight
[SAE PAPER 87-527] p 162 A89-16150
Biomedical payload of the French-Soviet long duration flight
[SAE PAPER 87 541] p 152 A89-16159
Support of life science research in space by the DFVLR Microgravity User Support Center (MUSC)
[SAE PAPER 87-546] p 110 A89-16162
Evolution on the Space Station - Of mice and men
[SAE PAPER 871457] p 153 A89-21116
Water management requirements for animal and plant maintenance on the Space Station
[SAE PAPER 871460] p 61 A89-21125
Scientific objectives and functional requirements of life sciences in the Space Station p 104 A89-21170
Mankind and space -- Russian book
p 164 A89-29411
BIOGENY
Exobiology and life science p 118 N89-15308
BIOLOGICAL EFFECTS
Radiation problems in manned space flight with a view to the Space Station p 132 N89-19038
BIOLOGICAL MODELS (MATHEMATICS)
A theoretical concept for static changes and shape changes in weightlessness p 137 N89-15385
BIOMASS
Design concepts for bioreactors in space
p 45 N89-17179
BIOPROCESSING
Design concepts for bioreactors in space
p 45 N89-17179
BIOREACTORS
Sunlight supply and gas exchange systems in microalgae bioreactor p 61 N89-12218
Design concepts for bioreactors in space
p 45 N89-17179
BIOTECHNOLOGY
The protein crystallization facility (PCF) for Eureca
[AF PAPER 87-612] p 110 A89-16282
Biotechnology opportunities on Space Station
[SAE PAPER 871468] p 154 A89-21124
BLOOD
An assessment of clinical chemical sensing technology for potential use in space station health maintenance facility
[NASA-CR-172010] p 158 N89-12505
BONE DEMINERALIZATION
Bones and stones in space - integrating the medical and scientific questions
[SAE PAPER 871465] p 153 A89-21123
BOOMS (EQUIPMENT)
The effect of photoelectrons on boom-satellite potential differences during electron beam ejection
[AD-A190380] p 75 A89-20350
Solution of structural analysis problems on a parallel computer
[AIAA PAPER 88-2287] p 32 A89-32240
Pinhole occulter experiment
[NASA-CR-179208] p 116 N88-11481
Development of the Extendable and Retractable Mast (ERM). Design phase 2: Volume 1 -- spacecraft payloads
[RP-2010-0000-DD/09] p 91 N89-18709
BOOSTER RECOVERY
A two stage launch vehicle for use as an advanced space transportation system for logistics support of the space station
[NASA-CR-182572] p 107 N89-19008
BOOSTER ROCKET ENGINES
A two stage launch vehicle for use as an advanced space transportation system for logistics support of the space station
[NASA-CR-182572] p 107 N89-19008
BOTANY
Design and development of the life support subsystem of a laboratory model of the Botany Facility
[SAE PAPER 871518] p 43 A89-21184
Exobiology and botany facilities 1': EUROCA
p 148 N89-19009
BOUNDARY VALUE PROBLEMS
Convergence properties of modal costs for certain distributed-parameter systems p 20 A89-13 (-5/5)
The nonlinear behavior of a passive zero-spring-rate suspension system
[AIAA PAPER 89-1319] p 57 A89-32264
Multiple boundary condition test (MBCT) - Identification with mode shapes
[AIAA PAPER 89-1353] p 23 A89-32293
BRACKETS
Mechanical design of the ac bracket package for the #2 TD experiment
[PTS-67-4] p 145 N89-13379
BRAYTON CYCLE
Solar receiver for the Space Station Brayton engine
[ASME PAPER 87-GT-252] p 62 A89-11138
Collector and receiver designs for high temperature Brayton cycle for space application
[AF PAPER 87-229] p 64 A89-11463
BRIDGMAN METHOD
Analysis of low gravity tolerance of model experiments for space station: Preliminary results for directional solidification
[NASA-CR-182857] p 10 N89-19048
BUDGETS
Space Station cavorts past all obstacles
p 116 A89-10367
Feasibility study of a carbon dioxide observatory platform system: Volume 2: Programmatics
[NASA-CR-182804] p 116 N89-19114

C

CABIN ATMOSPHERES
A smoke removal unit
[SAE PAPER 871449] p 153 A89-21139
CABLES
Comparative study of cable construction for 20 kHz power distribution p 66 A89-11401
CAMERAS
Study of a payload for Columbus Polar Platform Earth observation demonstration mission: executive summary
[ESA-CR(P)-2412] p 116 N89-10079
CANADIAN SPACE PROGRAM
Canada's Space Station Program p 162 A89-24486
CANTILEVER BEAMS
Finite-element model for the thermoelastic analysis of large composite space structures p 14 A89-19632
Dynamics and control of a planar truss actuator
p 51 A89-31564
Active control of flexural vibrations in beams
p 16 N89-18892
CARBON DIOXIDE CONCENTRATION
Carbon Dioxide observations platform system (CO-OPS): Feasibility Study
[NASA-CR-179205] p 116 N89-19113
CARBON DIOXIDE REMOVAL
Stability of 5A-4A solid amine resin as a function of carbon dioxide absorption and steam desorption cycling
[SAE PAPER 871912] p 63 A89-21112
Electrochemically regenerable carbon dioxide/moisture control technology for an Advanced Extravehicular Mobility Unit
[SAE PAPER 871475] p 61 A89-21126
Development of a regenerable humidity and CO2 control system for an advanced EMU
[SAE PAPER 871471] p 61 A89-21127
Experimental study for carbon dioxide removal system in Space Station
[SAE PAPER 871516] p 43 A89-21161
An experimental study of the Bosch and the Sabatier CO2 reduction processes
[SAE PAPER 871517] p 61 A89-21162
The feasibility of Chlorella as the exchanger of CO2 for O2 and the food resources in the Space Station
p 43 A89-29136
CARBON FIBER REINFORCED PLASTICS
Solar converging method p 37 N89-12504
Integrity control of carbon fiber reinforced plastics (CFRP) structural elements. Conclusion with respect to the control methodology of CFRP primary structures in manned space flight and the implications to the design, analysis and testing of CFRP structural elements, executive summary
[MBB-FB-RS511-014-89] p 97 N89-16801
CARBON FIBERS
Carboflex - A new general purpose pitch based carbon fiber
p 94 A89-13202
Burst and rupture behavior of carbon-fiber metal-liner pressure vessels for 30-year operation in space
[NASA PAPER 88-2979] p 19 A89-31591
A composite structural system for a large collapsible space antenna p 19 A89-31603
Carbon fiber reinforced glass matrix composites for space based applications
[AD-A184355] p 96 N89-12546
CARDIOVASCULAR SYSTEM
Cardiovascular adaptation to zero-g during a long term flight (237 days) on board the Salyut 7 Soviet space station (1984)
p 138 N89-19925
Cardiac and peripheral circulation assessment by ultrasound on 3 astronauts during two 7-day space flights (1982 Salyut 7 - 1985 STS 51G)
p 158 N89-19921
CARGO SPACECRAFT
Rail accelerator direct launch system for space cargo
[87-PAPER-P-67-010] p 162 A89-15944
STS propellant scavenging systems study. Part 2, volume 2: Cost and WBS dictionary
[NASA-CR-179276] p 91 N89-17717
CASCADE CONTROL
Decentralized hierarchical control for large flexible spacecraft
[9550-UR-90-7-87] p 52 A89-27992
CATALOGS
Component data base for space station resistojet auxiliary propulsion
[NASA-CR-180838] p 91 N89-17791
CATALYSIS
Catalytic processes for space station waste conversion
[NASA-CR-177405] p 44 N89-10491
CATALYSTS
In situ test of a 22 Newton (5.0/5) hydrazine rocket
[NASA TM-100232] p 79 N89-11750
CATASTROPHE THEORY
Progress towards autonomous, intelligent systems
[87-FAST-01-87-01] p 87 A89-15823
CELESTIAL MECHANICS
Construction of a full solution for an integrable case of the problem of the motion of two coupled bodies
p 115 A89-26087
CENTRAL PROCESSING UNITS
Central processing unit for fault tolerant computing in Columbus p 120 A89-21254
CENTRIFUGES
Need, utilization, and configuration of a large, multi-G centrifuge on the Space Station p 105 A89-29140
Preliminary analysis of an integrated logistics system for CSSA payloads
[NASA-CR-4116] p 6 N89-19877
Preliminary analysis of an integrated logistics system for CSSA payloads. Volume 4: Supportability analysis of the 1.8m centrifuge p 6 N89-19481
CERAMIC MATRIX COMPOSITES
Carbon fiber reinforced glass matrix composites for space based applications
[AD-A184355] p 96 N89-12546
CERAMICS
Advanced materials technology '87: Proceedings of the Thirty second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr 6-9, 1987
p 1 A89-13126
CERTIFICATION
Recent advances in structural dynamics of large space structures
[AF PAPER 87-84] p 11 A89-15836
CHARACTERIZATION
Mechanical properties characterization of composite sandwich materials intended for space antenna applications
[NASA TM-89893] p 25 N89-10121
CHARGED PARTICLES
Electrostatic analyzers design for space investigation
p 131 A89-29623
Atmospheric science p 5 N89-15357
CHECKOUT
Development of an automated checkout, service, and maintenance system for an EVRS Space Station
[SAE PAPER 871497] p 124 A89-21149
CHEMICAL ANALYSIS
An assessment of clinical chemical sensing technology for potential use in space station health maintenance facility
[NASA-CR-172010] p 158 N89-12505
CHEMICAL COMPOSITION
Exobiology and life science p 118 N89-15308
CHEMICAL PROPULSION
Space station oribaard propulsion system Technology study
[NASA-CR-179259] p 90 N89-10896
CHEMICAL RELEASE MODULES
The combined release and radiation effects satellite, a joint NASA/DOD program p 131 N89-10851
CHONDRULE
Astrophysics and the solar nebula
p 119 N89-15393
CHROMIC ACID
Chromic acid anodizing of aluminum foil
[NASA-CR-179417] p 97 N89-15077

173

CIRCADIAN RHYTHMS
Implications of shiftwork in space for human physiology experiments p 129 N89-10942
CLADDING
Development and properties of aluminum-clad graphite-epoxy tubes for space structures
[AIAA PAPER 88-2472] p 10 A88-31380
CLASSICAL MECHANICS
Construction of a full solution to the problem of the relative motion of a system of two bodies p 111 A88-29698
CLEANING
Fourteenth Space Simulation Conference: Testing for a Permanent Presence in Space
[NASA-CP-2466] p 5 N89-10929
CLINICAL MEDICINE
An assessment of clinical chemical sensing technology for potential use in space station health maintenance facility
[NASA-CR-172012] p 130 N89-12509
Basic results of medical studies during prolonged manned flights on board the Salyut-7/Soyuz-T orbital complex
[NASA-TT-20217] p 147 N89-19182
Full scale architectural simulation techniques for space stations p 10 N89-19667
CLOSED ECOLOGICAL SYSTEMS
Inflight microbial analysis technology
[SAE PAPER 871493] p 62 A88-21167
Space farming in the 21st century p 109 A88-29237
Catalytic processes for space station water conversion
[NASA-CR-177427] p 64 N89-10491
Progress in European CELSS activities p 64 N89-12252
Sunlight supply and gas exchange systems in microalgal bioreactor p 64 N89-12258
An overview of Japanese CELSS research activities p 64 N89-12267
Controlled Ecological Life Support Systems (CELSS) conceptual design option study
[NASA-CR-177421] p 64 N89-14025
Controlled Ecological Life Support Systems (CELSS) physiochemical waste management systems evaluation
[NASA-CR-177422] p 65 N89-14026
Space station accommodations for life sciences research facilities. Phase 1: Conceptual design and programmatics studies for Missions SAAM307, SAAM302 and the transition from SAAM307 to SAAM302. Study results
[NASA-CR-179044] p 104 N89-15829
Design concepts for bioreactors in space p 65 N89-17179
CLUSTERS
Physics and chemistry p 110 N89-15358
COAGULATION
Astrophysics and the solar nebula p 110 N89-15355
COALESCING
Atmospheric science p 5 N89-15357
COAXIAL CABLES
Coaxial tube array space transmission line characterization p 75 A88-11865
COLLISION AVOIDANCE
Department of Defense space policy and the development of a global policy for the control of space debris
[AF PAPER 87-575] p 175 A88-10186
Safe rendezvous approach to a space station by impulsive transfers and continuous thrust arcs p 111 N89-19486
COLLISIONS
Dynamics of orbiting debris clouds and the resulting collision hazard to spacecraft
[AF PAPER 87-571] p 175 A88-10183
COLUMBUS SPACE STATION
Columbus takes shape - Europe's Space Station approaches decision time p 132 A88-10878
ESTEC the deployable mast for Columbus - Extendible and Retractable Mast p 11 A88-15278
Columbus Space Segment definition p 133 A88-15293
Development of the resource module for the European space station programme Columbus p 134 A88-15294
MTFF operational design features p 134 A88-15296
The Columbus system baseline and interfaces p 134 A88-15297
Columbus Attached Pressurized Module configuration - MTFF Pressurized Module configuration p 134 A88-15298
European Polar Platform operations and logistics
[AF PAPER 87-15] p 135 A88-15312
Logistics flow for Columbus MTFF
[AF PAPER 87-39] p 123 A88-15829
On-orbit servicing and cost effectiveness of Columbus polar platform concepts
[AF PAPER 87-42] p 123 A88-15831
Columbus, present programme status
[AF PAPER 87-62] p 135 A88-15841
The Columbus space segment
[AF PAPER 87-66] p 136 A88-15845
Man tended free flyer interior equipment for manned and automated operation
[AF PAPER 87-75] p 136 A88-15850
Trades and problems in the definition of the Columbus operation concept
[AF PAPER 87-80] p 136 A88-15857
Columbus pressurized modules: Maintenance and supply concepts - Approach and development for a Space Station long term support
[AF PAPER 87-86] p 137 A88-15860
The potential of Columbus element utilization
[AF PAPER 87-94] p 137 A88-15865
Preparation of Space Station/Columbus utilization
[AF PAPER 87-95] p 137 A88-15866
The utilization of the Columbus Polar Platform
[AF PAPER 87-98] p 150 A88-15869
Configuration drivers for the European Polar Platform
[AF PAPER 87-104] p 137 A88-15873
Columbus pressurized modules - A challenging opportunity for microgravity research and application
[AF PAPER 87-375] p 137 A88-16050
The Columbus programme - European steps towards the considered development of near-earth space p 138 A88-19805
Damming the data stream from space p 95 A88-19900
Columbus ECLSS
[SAE PAPER 871439] p 139 A88-21093
Thermal control definition of Columbus pressurized modules
[SAE PAPER 871483] p 139 A88-21138
The Columbus Attached Pressurized Module - System and management aspects of international cooperation p 139 A88-21252
Central processing unit for fault tolerant computing in Columbus p 139 A88-21254
A data base approach towards Columbus payload accomodation p 99 A88-21257
The Eureca concept and its importance for preparing the Columbus Programme p 140 A88-21524
Strengthening graphite-epoxy composites p 95 A88-21554
The Columbus Programme p 140 A88-21555
The Columbus system aspects p 140 A88-21556
Columbus pressurized module p 140 A88-21557
The Columbus polar platform p 140 A88-21558
The Resource Module p 140 A88-21559
Electrical power for Columbus - An important cross-element task p 140 A88-21560
Fokker subsystem responsibilities in Columbus B phase studies p 141 A88-21561
Aerospatiale studies for ICC and ACE - Initial Operational Capability and Autonomous Operating Capability p 141 A88-21562
Columbus operation and utilization p 141 A88-21563
Columbus utilization preparation - Status of ongoing studies p 141 A88-21565
Space science with Columbus p 141 A88-21567
Earth observation and the Space Station p 112 A88-21569
Partnership, a key issue in the International Space Station cooperation p 142 A88-21575
Evolution of data management systems from Spacelab to Columbus
[MBB-UR-E 068-87] p 99 A88-23581
Future European ground segment -- for Columbus Space Station
[MBB-UR-E 076-87] p 142 A88-23583
Man Tended Free Flyer configurations and servicing scenarios
[MBB-UR-E 084-87] p 151 A88-23600
Man Tended Free Flyer utilization aspects
[MBB-UR-E 091-87] p 142 A88-23601
Orbital systems p 143 A88-28170
Metallurgy laboratory for Columbus, executive summary
[BNWAS-913-CA-73] p 145 N89-10980
Thermophysical Properties Measurement Facility (TPMF) -- Columbus space station
[ESA-CR(P)-2417] p 9 N89-10981
A preliminary study of a fluid science laboratory for space station (Columbus). Part 4: Executive summary
[NLR-TR-87029-L-PT-4] p 79 N89-11570
Considerations concerning a thermal joint for a deployable or steerable battery radiator for the Columbus Polar Platform
[NLR-TR-86005-G] p 37 N89-11739
Commercial Opportunities for Remote Sensing with Polar Platforms
[ESA-SP-269] p 117 N89-12131
Possible commercial use of the polar platforms -- Columbus p 160 N89-12132
Payload configurations and serviceability -- Columbus Polar Platforms p 117 N89-12133
Legal protection of the Polar Platform's users p 140 N89-12135
Confidentiality of data -- Columbus Polar Platforms p 140 N89-12136
X-band SAR for a European remote sensing payload p 117 N89-12140
Antromag: A particle spectrometer for the Space Station
[PNE-PR(87)T-557] p 119 N89-14236
Columbus pressurized module utilization study, executive summary
[CS-RP-AI-027] p 146 N89-15685
Allowable gravity levels for Spacelab, Columbus and EURECA -- materials science
[SP-R-66.125-2] p 132 N89-15364
Docking/Berthing Subsystem (DBS) Development part 1: Latching analysis -- Columbus
[ESA-CR(P)-2479] p 40 N89-15605
Scientific objectives and functional requirements of life sciences in the Space Station p 156 N89-16264
AURIC: A proposal for flying auroral imaging observatory on the Polar Platform in the Space Station/Columbus program p 119 N89-16268
Technical aspects of future ocean colour remote sensing p 119 N89-16298
Polar platform element of Space Station: Mission objectives, European priorities, candidate instrumentation and selection procedure p 119 N89-16779
Space station overview p 167 N89-16780
Use of Space Station for space science p 120 N89-16782
Microgravity payloads and missions for Space Station: Some issues affecting compatibility with other payloads p 120 N89-16783
The Columbus program: an overview p 146 N89-16784
Coorbiting Platform Utilization Study (CPLUS), executive summary -- Columbus
[SSL-RP-4000-DOC-8609-85-F] p 121 N89-16788
Columbus feasibility studies. Volume 1: Requirements and system concept
[ETN-88-91073] p 146 N89-16789
Columbus feasibility studies. Volume 2: Element constituents, mechanical
[ETN-88-91074] p 146 N89-16800
Columbus feasibility studies. Volume 3: Avionics, systems
[ETN-88-91075] p 146 N89-16801
Columbus feasibility studies. Volume 5: Programmatics
[ETN-88-91076] p 147 N89-16802
Model of space platform electromagnetic (EMC) configuration
[ESA-CR(P)-2536] p 9 N89-16819
Study on long term evolution towards European manned space flight. Volume 1: Executive summary
[MBB-RAS-504-87-VOL-1] p 147 N89-17960
Project management in astronautics: From Spacelab to Columbus
[MBB-UPM-940-87] p 147 N89-17958
Columbus feasibility studies. Volume 4: Integration, test and operations
[ETN-88-90570] p 147 N89-19814
Man-Tended Free Flyer operational design features p 129 N89-19495
Mission profiles of the MTFF co-orbiting with the US Space Station p 6 N89-19497
Cost-effective orbit transfer modes for satellite retrieval and servicing -- Space Station p 61 N89-19499
Assembly of user systems at Space Station p 121 N89-19490
Analysis of R&D operations in manned space missions p 61 N89-19494
On a knowledge based assisted system for highly autonomous control of experiment manipulators in the Man-Tended Free Flyer p 92 N89-19505
Promising concepts for ground-to-orbit experiment transportation -- Columbus p 91 N89-19518
Columbus Simulation Facility (CSF) p 148 N89-19502
External payload servicing: Operational requirements and technology p 129 N89-19501
Microgravity User Support Center (MUSC) for EURECA, Spacelab and Columbus missions p 149 N89-19947
Animal research on the Space Station p 159 N89-19884

COMBUSTION
Techniques for fire detection p 156 N88-12521
Fire-related standards and testing p 156 N88-12522
Fire-related medical science p 156 N88-12525
Space station internal environmental and safety concerns p 158 N88-12527
Microgravity combustion fundamentals p 79 N88-12528
Ignition and combustion of metals in oxygen p 79 N88-12530

COMBUSTION CONTROL
Study of industry requirements that can be fulfilled by combustion experimentation aboard space station [NASA-CR-180864] p 167 N88-19377

COMBUSTION PHYSICS
Spacecraft Fire Safety [NASA-CP-2476] p 156 N88-12520
Microgravity combustion fundamentals p 79 N88-12528
Spacecraft material flammability testing and configurations p 96 N88-12529

COMETS
Exobiology and life science p 119 N88-15358

COMMAND AND CONTROL
Telerobotics and orbital laboratories - An end-to-end analysis and demonstration [SAE PAPER 87.27] p 83 A88-15819

COMPANDS AND MODULES
Optimization techniques applied to passive measures for orbital spacecraft survivability [NASA-CR-179216] p 5 N88-12532

COMMERCIAL ENERGY
Photovoltaics for commercial solar power applications. Proceedings of the Meeting, Cambridge, MA, Sept. 18, 19, 1986 [SPIE-706] p 70 A88-21601

COMMERCIAL SPACECRAFT
The commercial use of space stations. The legal framework of trans-Atlantic cooperation. International Colloquium, Hanover, Federal Republic of Germany, June 12, 13, 1986. Reports [DGLR-BERICHT-86-02] p 160 A88-13443
Commercial launch systems - The foreseeable future for Ariane p 161 A88-13460
Pathfinder technologies for bold new missions - U.S. research and development program for space exploration [IAF PAPER 87-46] p 1 A88-15832
Economic benefits of the Space Station to commercial communication satellite operators [IAF PAPER 87-622] p 163 A88-16215

COMMINUTION
Planetary science p 5 N88-11306

COMMUNICATION EQUIPMENT
Automatic antenna switching design for extra vehicular Activity (EVA) communication system p 77 N88-14883

COMMUNICATION NETWORKS
Prospects on future EVA communications [AIAA PAPER 88-0767] p 70 A88-27542
Geostationary tether satellite system and its application to communications systems p 115 A88-28974
Communications payload concepts for geostationary facilities [NASA-TM-100154] p 76 N88-13513
Development of a graphical display on the DMS test bed p 101 N88-14864
High data rate modem simulation for the space station multiple access communications system p 101 N88-14870

COMMUNICATION SATELLITES
Large flexible solar arrays p 11 A88-15277
The DFS platform and its applications - German communication satellite [IAF PAPER 87-470] p 138 A88-16119
Development of on-board satellite communications equipment in the Geostationary Platform era [IAF PAPER 87-495] p 110 A88-16136
Economic benefits of the Space Station to commercial communication satellite operators [IAF PAPER 87-622] p 163 A88-16215
The Spacebus platforms [AIAA PAPER 88-0775] p 115 A88-27535
Communication satellite technology trends p 76 N88-10088
Study of mobile communications payload for Columbus Polar Platforms [ITS-TR-056A-88] p 76 N88-10220
Communications satellite systems operations with the space station. Volume 3: Supplementary technical report [NASA-CR-180875] p 17 N88-15704

COMMUNICATION THEORY
Intelligent man/machine interfaces on the space station p 90 N88-16418

COMPATIBILITY
Compatibility of dispersion-strengthened platinum with monopropellants [NASA-TP-2780] p 79 N88-12536
Microgravity payloads and missions for Space Station: Some issues affecting compatibility with other payloads p 120 N88-16783

COMPENSATORS
Design of robust line-of-sight pointing control system for the SCOLE configuration p 54 A88-27367
A homotopy algorithm for solving the optimal projection equations for fixed-order dynamic compensation - Existence, convergence and global optimality p 16 A88-27401
Particle occulter experiment [NASA-CR-179206] p 116 N88-11481

COMPETITION
Space station: Leadership for the future [NASA-PAM-509(8-87)] p 165 N88-10072

COMPLEX SYSTEMS
Progress towards autonomous, intelligent systems [IAF PAPER 87.31] p 83 A88-15823
Synthesis of the flexible structures of complex systems p 15 A88-27146
On local state feedback and stability domain estimation of nonlinear large scale systems p 160 A88-29265

COMPONENT RELIABILITY
[illegible] AR PSAD 88 PSTA - Programs for evaluating the availability and maintenance of space systems p 125 A88-27778

COMPOSITE MATERIALS
Thermal response of integral multicomponent composites to a high-energy aerothermodynamic heating environment with surface temperature to 1600 K p 10 A88-12591
Advanced materials technology '87: Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr. 6-9, 1987 p 1 A88-13126
Novel composite materials for space structures and systems p 10 A88-13186
Stress and deformation analysis and tests of composite structures for space application [IAF PAPER 87.312] p 12 A88-16011
Large space structures - Structural concepts and materials [SAE PAPER 872429] p 17 A88-30999
Response of composite materials to the Space Station orbit environment [AIAA PAPER 88-2476] p 95 A88-31390
Passive damping for space truss structures [AIAA PAPER 88-2469] p 24 A88-32360
Structures and Materials Working Group report p 25 N88-10093
Mechanical properties characterization of composite sandwich materials intended for space antenna applications [NASA-TM-88893] p 25 N88-10121

COMPOSITE STRUCTURES
Spacecraft solar array substrate development p 68 A88-13187
Fabrication and assembly of an advanced composite Space Station telephoto cell p 11 A88-13189
Development of composite facets for the surface of a space-based solar dynamic concentrator p 70 A88-18230
Finite-element model for the thermoelastic analysis of large composite space structures p 14 A88-18632
A composite structural system for a large collapsible space antenna p 19 A88-31403
Outgassing of spacecraft composites p 95 A88-31404
Recent advances in dynamics of composite structures p 19 A88-31427
Structures and Materials Working Group report p 25 N88-10093
Space station structures development [NASA-CR-179261] p 30 N88-16792
Integrity control of carbon fiber reinforced plastics (CFRP) structural elements. Conclusion with respect to the control methodology of CFRP primary structures in manned space flight and the implications to the design, analysis and testing of CFRP structural elements, executive summary [MBB-TR-M8517-014/85] p 97 N88-16824

COMPRESSORS
Vapor compression distiller and membrane technology for water revitalization p 58 A88-17072

COMPUTATIONAL GRIDS
Computer-aided modeling and prediction of performance of the modified Lundell class of alternators in space station solar dynamic power systems [NASA-CR-182538] p 74 N88-19090

COMPUTER AIDED DESIGN
Design and development of a computer-assisted ground control technique for Space Station robotics p 62 A88-15264
Capabilities and special features concerning structural optimization of spacecraft structures [IAF PAPER 87-329] p 12 A88-16016
FACILE - A computer program for Space Station facilities layout and activity simulation [SAE PAPER 871415] p 7 A88-21579
ITDS - A program for interactive design and analysis of advanced active thermal control systems [SAE PAPER 871421] p 34 A88-21585
A computer aided engineering tool for ECLS systems [SAE PAPER 871423] p 96 A88-21057
Preliminary design of the Space Station external thermal control system [SAE PAPER 871505] p 35 A88-21151
The use of computer graphic simulation in the development of on-orbit tele-robotic systems p 65 A88-21646
Solar dynamic heat receiver thermal characteristics in low earth orbit [AIAA PAPER 88-0472] p 71 A88-22348
Optimum design of structures with multiple constraints p 16 A88-29042
Control-augmented structural synthesis [AIAA PAPER 88-1014] p 55 A88-29043
An application of MSC/NASTRAN in the interdisciplinary analysis of large space-based structures p 17 A88-29819
A recursive pole-placement method for large flexible structures p 19 A88-31567
Convergence properties of modal costs for certain distributed parameter systems p 20 A88-31570
New feedback design methodologies for large space structures: A multi-criterion optimization approach p 59 N88-12535
FME Assist: A knowledge-based approach to Failure Modes and Effects Analysis p 101 N88-16335
Computer aided modeling and prediction of performance of the modified Lundell class of alternators in space station solar dynamic power systems [NASA-CR-182538] p 74 N88-19090
Columbus Simulation Facility (CSF) p 160 N88-19522

COMPUTER ASSISTED INSTRUCTION
Onboard training for the Space Station [AIAA PAPER 88-0445] p 154 A88-22331

COMPUTER DESIGN
Spaceborne optical disk controller development p 98 A88-12755

COMPUTER GRAPHICS
The use of computer graphic simulation in the development of on-orbit tele-robotic systems p 65 A88-21646
Structural model verification with LQG theory - Linear Quadratic Optimization [AIAA PAPER 88-2360] p 23 A88-32300
Development of a graphical display on the DMS test bed p 101 N88-14864
FME Assist: A knowledge-based approach to Failure Modes and Effects Analysis p 101 N88-16335

COMPUTER INFORMATION SECURITY
Applying technology to systems. Aerospace Computer Security Conference, 3rd, Orlando, FL, Dec. 7-11, 1987. Technical Papers p 9 A88-26209
Space Station Program threat and vulnerability analysis [AIAA PAPER 87.3082] p 104 A88-26210
Access control for a safety critical distributed system interface set [AIAA PAPER 87.3083] p 100 A88-26211
Confidentiality of data - Columbus Polar Platforms p 145 N88-12136

COMPUTER NETWORKS
Use of a distributed microprocessor network for control of the Space Station electrical power system p 67 A88-11856
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems p 89 N88-16373
Foundation: Transforming data bases into knowledge bases p 102 N88-16423

COMPUTER PROGRAM INTEGRITY
Space Station Program threat and vulnerability analysis [AIAA PAPER 87.3082] p 104 A88-26210

COMPUTER PROGRAMMING
AIAA Computers in Aerospace Conference, 6th, Wakefield, MA, Oct. 7-9, 1987, Technical Papers p 81 A88-12526
Space Station Mission Planning System (MPS) development study. Volume 2 [NASA-CR-179200] p 4 N88-10048

Space Station Mission Planning Study (MPS) development study. Volume 3: Software development plan
(NASA-CR-175203) p 4 N88-10049
Task-level robot programming: Integral part of evolution from teleoperation to autonomy p 91 N88-17279
Progress toward a cosmic dust collection facility on space station
(NASA-CR-182427) p 121 N88-19566

COMPUTER PROGRAMS
FACILE - A computer program for Space Station facilities layout and activity simulation
(SAE PAPER 871415) p 7 A88-21079
G189 computer program modeling of environmental control and life support systems for the Space Station
(SAE PAPER 871427) p 39 A88-21090
Approaches and possible improvements in the area of multibody dynamics modeling
(NASA-CR-179227) p 29 N88-14857
Development of a graphical display on the DMS test bed p 101 N88-14964
A space transportation system operations model
(NASA-TM-100481) p 9 N88-14999
The feasibility of using TAE as the UIL for the space station and for other internal NASA tasks and projects p 9 N88-15618
Third Conference on Artificial Intelligence for Space Applications, part 1
(NASA-CP-2492-Pt-1) p 89 N88-16360
KBS V and V as related to automation of space station subsystems. Rationale for a KBS lifecycle p 9 N88-16375
Intelligent man/machine interfaces on the space station p 90 N88-16418

COMPUTER SYSTEMS DESIGN
Study of fault tolerant techniques for satellite data handling
(FTT/REP/0001/SAAB) p 101 N88-13860
Expert system study for spacecraft management
(TL-2699-(SS-1) p 101 N88-15004
Can space station software be specified through Ada? p 9 N88-15622
EUROSIM: A design concept for an in-orbit operations simulator p 148 N88-19517
Definition of the EUROSIM simulation subsystem p 148 N88-19532

COMPUTER SYSTEMS PERFORMANCE
Expert system applications in spacecraft subsystem controllers p 90 N88-17254

COMPUTER SYSTEMS PROGRAMS
Thermal structural control modeling techniques — spacecraft
(FOK-TR-R-86-030) p 39 N88-15829

COMPUTER TECHNIQUES
Development of a thermal control coating for space suits
(SAE PAPER 871474) p 34 A88-21129

COMPUTER VISION
Focus of attention in systems for visual monitoring of experiments p 112 A88-21658
Vision technology/algorithms for space robotics applications p 90 N88-17267
Telerobotic truss assembly p 91 N88-17272

COMPUTERIZED SIMULATION
Computer modeling and simulation of a 20kHz ac distribution system for Space Station p 66 A88-11827
Simulation tools for the development of an autonomous rendezvous and docking system p 47 A88-13572
Simulation and control of a Space Station air revitalization system
(SAE PAPER 871425) p 7 A88-21089
The use of computer graphic simulation in the development of on-orbit tele-robotic systems p 65 A88-21646
System architecture for telerobotic servicing and assembly tasks p 66 A88-21649
Aeroassisted orbital transfer vehicle guidance performance in the presence of density dispersions
(AIAA PAPER 88-0302) p 150 A88-22017
Distributed systems approach to the identification of flexible structures p 15 A88-22606
REPPRE/REPSIM/REPSTA - Programs for evaluating the availability and maintenance of space systems p 125 A88-27776
Design and verification of the FLECS test structure — Flexible ECS-type structure p 54 A88-27779
An application of MSC/NASTRAN in the interdisciplinary analysis of large space-based structures p 17 A88-29818
Space Station probability of no penetration due to meteoroid and orbital debris impact
(AIAA PAPER 88-2464) p 18 A88-31387
Orbit lifetime characteristics for Space Station
(AIAA PAPER 88-2490) p 55 A88-31390
Modeling of environmentally induced effects within satellites. Part 1: NASCAP modeling of satellites p 58 N88-11721
Electrodynamic tether system study
(NASA-CR-172024) p 117 N88-11737
Teleoperator and robotics system analysis
(NASA-CR-179220) p 67 N88-12105
Analytical investigation of the dynamics of tethered constellations in Earth orbit (phase 2)
(NASA-CR-179219) p 117 N88-12533
Optimal control of large space structures via generalized inverse matrix
(NASA-CR-182336) p 59 N88-13907
Dynamics formulations for the real-time simulation of constrained motion p 60 N88-14872
Knowledge-based simulation p 102 N88-16404
Simulation test beds for the space station electrical power system
(NASA-TM-100786) p 74 N88-17715
Columbus Simulation Facility (CSF) p 148 N88-19522

CONCENTRATORS
A novel photovoltaic power system which uses a large area concentrator mirror p 65 A88-11811
Development of an advanced photovoltaic concentrator system for space applications p 65 A88-11812
Solar converging method p 37 N88-12504
Solar concentrator advanced development program, task 1
(NASA-CR-179889) p 74 N88-18368

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ECEC '87: Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volumes 1, 2, 3, & 4 p 63 A88-11776
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Guidance and control 1987: Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Jan. 31-Feb. 4, 1987 p 51 A88-16976
Remote sensing: Earth's surface and atmosphere: Proceedings of Workshop X and the Topical Meeting of the 28th COSPAR Plenary Meeting, Toulouse, France, June 30-July 11, 1986 p 111 A88-17026
Looking ahead for materials and processes: Proceedings of the Eighth SAMPE (European Chapter) International Conference, La Baule, France, May 19-21, 1987 p 94 A88-20701
Strengthening graphite-epoxy composites p 95 A88-21554
Photovoltaics for commercial solar power applications: Proceedings of the Meeting, Cambridge, MA, Sept. 18, 19, 1986
(SPIE-706) p 70 A88-21601
Space Station automation II: Proceedings of the Meeting, Cambridge, MA, Oct. 28-30, 1986
(SPIE-729) p 84 A88-21631
Proceedings of the Fourth Annual L5 Space Development Conference p 163 A88-22000
Space nuclear power systems 1986: Proceedings of the Third Symposium, Albuquerque, NM, Jan. 13-16, 1986 p 71 A88-22676
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Spacecraft 2000
(NASA-CP-2473) p 106 N88-19084
Fourteenth Space Simulation Conference: Testing for a Permanent Presence in Space
(NASA-CP-2486) p 5 N88-10829
Space Construction
(NASA-CP-2490) p 26 N88-10870
Space Environment Technology — conference
(ISBN-2-85428-170-5) p 132 N88-11702
Commercial Opportunities for Remote Sensing with Polar Platforms
(ESA-SP-269) p 117 N88-12131
Spacecraft Fire Safety
(NASA-CP-2476) p 150 N88-12520
Cryogenic Fluid Management Technology Workshop. Volume 1: Presentation material and discussion
(NASA-CP-10001) p 90 N88-15924
Third Conference on Artificial Intelligence for Space Applications, part 1
(NASA-CP-2492-Pt-1) p 89 N88-16360
Proceedings of the ESA Workshop on Co-Orbiting Platform Elements (COPE)
(ESA-SP-1093) p 191 N88-16777
Proceedings of the 2nd European In-Orbit Operations Technology Symposium
(ESA-SP-272) p 129 N88-19484
Progress toward a cosmic dust collection facility on space station
(NASA-CR-182427) p 121 N88-19566

CONGRESSIONAL REPORTS
National Aeronautics and Space Administration Authorization Act, 1988
(PUB-LAW-100-147) p 165 N88-12422
Department of Housing and Urban Development Independent Agencies Appropriations for fiscal year 1988: Thursday, 9 April 1987 National Aeronautics and Space Administration p 166 N88-12424
Department of Housing and Urban Development Independent Agencies Appropriations for fiscal year 1988: Friday, 10 April 1987 National Aeronautics and Space Administration p 166 N88-12425
National Aeronautics and Space Administration space station proposal, fiscal year 1988
(S-HRG-100-328) p 166 N88-14043
The 1988 NASA (National Aeronautics and Space Administration) authorization
(GPO-80-245) p 166 N88-14044
The 1988 National Aeronautics and Space Administration (NASA) authorization
(GPO-76-600) p 166 N88-14854
Advancing automation and robotics technology for the space station and for the US economy: Submitted to the United States Congress May 15, 1987
(NASA-TM-89811) p 68 N88-15817
Advancing automation and robotics technology for the space station and for the US economy: Submitted to the United States Congress October 1, 1986
(NASA-TM-89190) p 69 N88-15818

CONSTRAINTS
Attitude Control Working Group report p 57 N88-10099
Dynamics formulations for the real-time simulation of constrained motion p 60 N88-14872

CONSTRUCTION
Mission Peculiar Equipment Support Structure: A platform for space construction p 26 N88-10874
Marshall Space Flight Center's role in EASE/ACCESS mission management p 27 N88-10875
Results of the ACCESS experiment p 27 N88-10880
Investigation of design concepts for large space structures to support military applications
(AD-A186096) p 29 N88-15000
State-of-the-art technologies for construction in space: A review
(AD-A186412) p 31 N88-19483

CONSTRUCTION MATERIALS
Space environmental effects on polymeric materials
(NASA-CR-182418) p 97 N88-15082

CONSUMABLES (SPACECREW SUPPLIES)
Orbital Spacecraft Consumables Resupply System (OSCRS): Monopropellant application to space station and OMV automatic refueling impacts of an ELV launch, volume 4
(NASA-CR-172029) p 126 N88-11741
The determination of nutritional requirements for Safe Haven Food Supply System (emergency/survival foods) p 45 N88-14856

176

CONTACTORS
Plasma contactors for use with electrodynamic tethers for power generation
(NASA-CR-182424) p 73 N88-16547

CONTAINERLESS MELTS
Preliminary study of a containerless processing facility for Columbus, executive summary
(ESA-ITT-AO/1-1,834/85/F) p 96 N88-10203

CONTAMINATION
Space station contamination considerations
p 131 N88-10859
A life test of a 22-Newton (5-lbf) hydrazine rocket
(NASA-TM-100232) p 79 N88-11750

CONTINUOUS WAVE LASERS
High intensity 5 eV O-atom exposure facility for material degradation studies p 96 N88-10847

CONTINUUM MODELING
Nondestructive construction error detection in large space structures
(AIAA PAPER 88-2460) p 18 A88-31383
Continuum modeling of large lattice structures: Status and projections
(NASA-TP-2767) p 26 N88-14115

CONTROL
Problem of control arisen during the implementation of scientific research program onboard the multipurpose orbital stations
(IAF PAPER 87-105) p 49 A88-15874
Guidance and control 1987; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Jan. 31-Feb. 4, 1987 p 51 A88-16976

CONTROL CONFIGURED VEHICLES
Control-augmented structural synthesis
(AIAA PAPER 88-1014) p 55 A88-28043
Structural tailoring and feedback control synthesis - An interdisciplinary approach
(AIAA PAPER 88-2206) p 21 A88-32177
Experimental studies of active members in control of large space structures
(AIAA PAPER 88-2207) p 58 A88-32178

CONTROL EQUIPMENT
CAMERA: Expert System for Space Station communications and tracking system management — Control and Monitor Equipment Resource Allocation
p 75 A88-15285

CONTROL MOMENT GYROSCOPES
Application of magnetic bearings to high-torque, satellite attitude control wheels p 47 A88-11908
Gyrostabilizer system of Kvant module
p 60 N88-16099

CONTROL SIMULATION
On the modeling and control of a flexible manipulator arm by joint actuators p 62 A88-14996
Experiments in advanced control concepts for space robotics - An overview of the Stanford Aerospace Robotics Laboratory
(AAS PAPER 87-044) p 93 A88-16999
Thermal structural control modeling techniques — spacecraft
(FOK-TR-R 86-030) p 38 N88-15828
A comparative survey of mathematical models for dynamic simulation of in-orbit manipulation operations
p 149 N88-19533

CONTROL STABILITY
Stability analysis for alternative force control schemes as applied to remote space teleoperation
(AAS PAPER 87-043) p 51 A88-16998
Lyapunov function gradient generated robust control in the absence of the nominal stabilizing control
p 54 A88-27404
On local state feedback and stability domain estimation of nonlinear large scale systems p 144 A88-29245
Survey on large scale system control methods
(NASA-CR-181556) p 59 N88-13374

CONTROL SYSTEMS DESIGN
An integrated approach to space station power system autonomous control p 67 A88-11853
Applications for power control within a Space Station module p 67 A88-11854
Application of advanced automation techniques in the Space Station electrical power system
p 75 A88-11855
Use of a distributed microprocessor network for control of the Space Station electrical power system
p 67 A88-11856
A concept for standard load center automation
p 67 A88-11857
Cooperating expert systems for power systems — Space Station resource allocation p 68 A88-11861
Robustness of active modal damping of large flexible structures p 11 A88-13829
Feedback control for attitude control system of the elastic vehicle p 48 A88-14596
On the hierarchical control of the Space Station common module thermal system p 33 A88-14980
Control of gripper position of a compliant link using strain gauge measurements p 49 A88-14995
On the modeling and control of a flexible manipulator arm by joint actuators p 62 A88-14996
Design and development of a computer assisted ground control technique for Space Station robotics
p 62 A88-15264
Development experience of the attitude control system using single-axis control moment gyros for long term orbiting space stations
(IAF PAPER 87-04) p 48 A88-15804
Solar sailing attitude control of large geostationary satellite p 50 A88-16260
Evaluation of control concepts for a large geostationary data relay satellite p 50 A88-16261
On control of tethered satellite systems
p 110 A88-16294
Design-to-performance — all controllers for Space Stations p 2 A88-16295
Control aspects of a European space manipulator system p 93 A88-16313
Pointing mount with active vibration isolation for large payloads
(AAS PAPER 87-033) p 103 A88-16993
Stability analysis for alternative force control schemes as applied to remote space teleoperation
(AAS PAPER 87-043) p 51 A88-16998
Experiments in advanced control concepts for space robotics - An overview of the Stanford Aerospace Robotics Laboratory
(AAS PAPER 87-044) p 93 A88-16999
ITDS - A program for interactive design and analysis of advanced active thermal control systems
(SAE PAPER 871421) p 34 A88-21095
Simulation and control of a Space Station air revitalization system
(SAE PAPER 871425) p 7 A88-21099
Development of a regenerable humidity and CO2 control system for an advanced EMU
(SAE PAPER 871471) p 41 A88-21127
Design of an ammonia two-phase Prototype Thermal Bus for Space Station
(SAE PAPER 871506) p 35 A88-21152
Autonomy, automation, and systems
p 65 A88-21640
An orbiting control station for free-flying teleoperators - Preliminary design methodology p 51 A88-21647
Techniques for assessment of flexible space structure control performance
(AIAA PAPER 88-0677) p 52 A88-22507
1987 American Control Conference, 6th, Minneapolis, MN, June 10-12, 1987, Proceedings. Volumes 1, 2, & 3
p 53 A88-27301
A parameter robust LQG design synthesis with applications to control of flexible structures
p 15 A88-27319
Robust stabilization under modal truncation and parameter variations p 15 A88-27325
Information prioritization for control and automation of space operations p 66 A88-27355
Decentralized control of third generation spacecraft
p 15 A88-27356
Active vibration control on the OSU flexible beam
p 15 A88-27357
Structural decomposition approach to design of robust decentralized controllers for large scale systems
p 53 A88-27358
A survey of decentralized control techniques for large space structures p 16 A88-27359
Design of robust line-of-sight pointing control system for the SCOLE configuration p 54 A88-27367
Control of distributed parameter systems with spillover using an augmented observer p 16 A88-27377
(M,N)-approximation - A system simplification method
p 54 A88-27402
Identification and control of flexible structures
p 54 A88-27788
Integrated control of large flexible structures
p 16 A88-29474
Dynamics and control characteristics of a reference Space Station configuration
(AIAA PAPER 88-2465) p 55 A88-31394
The impact of asymmetric physical properties on large space structures
(AIAA PAPER 88-2466) p 19 A88-31395
Experimental studies of active members in control of large space structures
(AIAA PAPER 88-2207) p 58 A88-32178
Control design challenges of large space systems and spacecraft control laboratory experiment (SCOLE)
(NASA-CR-179392) p 58 N88-11795
Wavefront error sensing
(NASA-CR-181504) p 79 N88-12030
Space station resistojet system requirements and interface definition study
(NASA-CR-180832) p 60 N88-12541
Survey on large scale system control methods
(NASA-CR-181556) p 59 N88-13374
Design of low order controllers for robust disturbance rejection in large space structures
(AD-A185202) p 59 N88-13376
Multisurface control mechanism for a deployable antenna. Far Infrared and Submillimeter Space Telescope (FIRST) technology study
(RP-FA-0803) p 120 N88-16807
Crew interface with a telerobotic control station
p 91 N88-17273
Sensitivity of active vibration control to structural changes and model reduction p 30 N88-17983
NASA/NBS (National Aeronautics and Space Administration/National Bureau of Standards) standard reference model for Telerobot Control System Architecture (NASREM)
(PB88-124773) p 92 N88-17999
On a knowledge based assisted system for highly autonomous control of experiment manipulators in the Man Tended Free Flyer p 92 N88-19505
A knowledge-based approach for sensory-controlled assembly operations p 128 N88-19506
Promising concepts for ground-to-orbit experiment teleoperation — Columbus p 93 N88-19518

CONTROL THEORY
A unified matrix approach applied to dynamic formulation of complex space structures with nonlinear hinge forces and torques
(IAF PAPER 87-348) p 13 A88-16036
Dynamics and control during slewing maneuvers
(IAF PAPER 87-353) p 49 A88-16043
1987 American Control Conference, 6th, Minneapolis, MN, June 10-12, 1987, Proceedings. Volumes 1, 2, & 3
p 53 A88-27301
Active modification of wave reflection and transmission in flexible structures p 16 A88-27395
Lyapunov function gradient generated robust control in the absence of the nominal stabilizing control
p 54 A88-27404
Identification and control of flexible structures
p 54 A88-27788
Analytical investigation of the dynamics of tethered constellations in Earth orbit (phase 2)
(NASA-CR-179219) p 117 N88-12533
Natural control of flexible space structures
p 58 N88-12534
Survey on large scale system control methods
(NASA-CR-181556) p 59 N88-13374
Analytical interactive approach for phenomena involving structures, thermal and control aspects. Volume 1: Theory — spacecraft structures
(ESA-CR(P)-2503-VOL-1) p 60 N88-16803
Analytical interactive approach for phenomena involving structures, thermal and control aspects. Volume 2: Toward the solution — spacecraft structures
(ESA-CR(P)-2503-VOL-2) p 60 N88-16804
Analytical interactive approach for phenomena involving structures, thermal, and control aspects. Volume 3: Executive summary — spacecraft structures
(ESA-CR(P)-2503-VOL-3) p 60 N88-16805
Safe and fuel minimum reference trajectories for closed loop controlled approaches — space stations
p 61 N88-19488

CONTROLLED ATMOSPHERES
Environmental control and life support testing at the Marshall Space Flight Center
(SAE PAPER 871453) p 40 A88-21113
Fire-related medical science p 156 N88-12525

CONTROLLERS
Spaceborne optical disk controller development
p 98 A88-12795
Integrated control of large flexible structures
p 16 A88-29474
Space station propulsion technology: Space station propulsion system test bed test plan
(NASA-CR-179201) p 79 N88-10104
Space station propulsion technology
(NASA-CR-179260) p 80 N88-15835
Telerobotic controller development p 89 N88-16370
Prototype space station automation system delivered and demonstrated at NASA p 45 N88-16442
Expert system applications in spacecraft subsystem controllers p 90 N88-17254
TDAS: The Thermal Expert System (TEXSYS) data acquisition system p 102 N88-17258

CONVERGENCE
Some thoughts on the convergence of the classical Rayleigh-Ritz method and the finite element method
(AIAA PAPER 88-2269) p 21 A88-32225

COOLING FINS
Roll-out-fin expandable space radiator concept
p 36 A88-30320
Advanced radiator concepts utilizing honeycomb panel heat pipes
(NASA-CR-172017) p 37 N88-12747

177

COOLING SYSTEMS
Hybrid honeycomb panel heat rejection system
[SAE PAPER 871419] p 34 A88-21083
The effect of maximum-allowable payload temperature on the mass of a multimegawatt space-based platform
[DE88-001821] p 37 N88-13381
CORIOLIS EFFECT
Artificial gravity - A countermeasure for zero gravity
[AF PAPER 87-533] p 105 A88-16156
CORONARY CIRCULATION
Cardiac and peripheral circulation assessment by ultrasound on 3 astronauts during two 7-day space flights (1982 Salyut-7 - 1985 STS-51G) p 158 N88-19921
COSMIC DUST
Exobiology and life science p 118 N88-15358
Progress toward a cosmic dust collection facility on space station
[NASA-CR-182427] p 121 N88-19566
COSMIC RAYS
Radiation hazards on space missions
p 130 A88-22919
Optimization of the parameters of a solar photoelectric system exposed to cosmic rays p 72 A88-28250
Determination of cosmic-ray characteristics on Salyut-7 p 131 A88-28349
Astromag: A particle spectrometer for the Space Station
[PREPRINT-557] p 118 N88-14336
Radiation problems in manned space flight with a view to the Space Station p 132 N88-19934
COSMONAUTS
Listening to the cosmonauts p 75 A88-13975
Cosmonaut behaviour in orbital flight situation - Preliminary ethological analysis
[AF PAPER 87-528] p 152 A88-16151
Mir - Soviet base in space p 129 A88-16378
COST ANALYSIS
Economic benefits of the Space Station to commercial communication satellite operators
[AF PAPER 87-622] p 163 A88-16215
Station pricing - Not just a question of 'How much does it cost?'
[AF PAPER 87-631] p 163 A88-16223
Solar power satellites p 70 A88-17023
Convergence properties of modal costs for certain distributed parameter systems p 20 A88-31570
The 1988 NASA (National Aeronautics and Space Administration) authorization
[GPO-80-248] p 166 N88-14044
Communications satellite systems operations with the space station. Volume 3: Supplementary technical report
[NASA-CR-180875] p 77 N88-16794
COST EFFECTIVENESS
Has manned space flight a future?
p 159 A88-10850
On-orbit servicing and cost effectiveness of Columbus polar platform concepts
[AF PAPER 87-42] p 123 A88-15831
Costs and benefits of future heavy Space Freighters
[AF PAPER 87-617] p 163 A88-16211
The economics of satellite retrieval
[AIAA PAPER 88-0843] p 164 A88-27584
Cost-effective orbit transfer modes for satellite retrieval and servicing — Space Station p 91 N88-19489
Cost effective development of a national test bed
[NASA-TM-100321] p 31 N88-19585
COST ESTIMATES
Space station: National Aeronautics and Space Administration's 1987 cost estimate
[PB87-220760] p 165 N88-10883
Carbon Dioxide observational platform system (CO-OPS): Feasibility Study
[NASA-CR-179225] p 119 N88-14113
Feasibility study of a carbon dioxide observational platform system. Volume 2: Programmatics
[NASA-CR-180404] p 119 N88-14114
COST REDUCTION
Trends to reduce development and operation costs for experiments of the future space laboratory
[AF PAPER 87-100] p 155 A88-15871
Lowering the costs of satellite operations - Lessons learned from the Solar Mesosphere Explorer (SME) mission
[AIAA PAPER 88-0549] p 7 A88-22412
COUNTERMEASURES
Artificial gravity - A countermeasure for zero gravity
[AF PAPER 87-533] p 105 A88-16156
COUPLED MODES
Modal coupling of structures with complex storage moduli p 20 A88-31580
COUPLING
Development of a coupled expert system for the spacecraft attitude control problem p 61 N88-17223
CREEP RUPTURE STRENGTH
Stress rupture behavior of carbon-fiber metal-lined pressure vessels for 30-year operation in space
[AIAA PAPER 88-2479] p 19 A88-31391
CREW WORKSTATIONS
Low-cost prototypes for human factors evaluation of Space Station crew equipment
[AF PAPER 87-553] p 152 A88-16170
An orbiting control station for free-flying teleoperators - Preliminary design methodology p 51 A88-21647
Personnel occupied woven envelope robot power
[NASA-CR-182367] p 66 N88-15196
CRYOGENIC COOLING
Cryogenic Fluid Management Technology Workshop. Volume 1: Presentation material and discussion
[NASA-CP-10001] p 80 N88-15924
Workshop on Technology Development Issues for the Large Deployable Reflector (LDR)
[NASA-CP-2467] p 32 N88-20235
CRYOGENIC EQUIPMENT
Af cryogenic and fluid management spacecraft technology program p 80 N88-15925
Orbital transfer vehicle studies overview
p 150 N88-15931
Large capacity cryopropellant orbital storage facility
p 80 N88-15932
CRYOGENIC FLUID STORAGE
Slosh dynamics in a toroidal tank — for orbit transfer vehicle cryogenic propellant storage p 78 A88-27868
Cryogenic Fluid Management Technology Workshop. Volume 1: Presentation material and discussion
[NASA-CP-10001] p 80 N88-15924
Af cryogenic and fluid management spacecraft technology program p 80 N88-15925
Large capacity cryopropellant orbital storage facility
p 80 N88-15932
Space environmental considerations for a long term cryogenic storage vessel p 80 N88-15933
CRYOGENIC FLUIDS
Cryogenic Fluid Management Technology Workshop. Volume 1: Presentation material and discussion
[NASA-CP-10001] p 80 N88-15924
Af cryogenic and fluid management spacecraft technology program p 80 N88-15925
SAMSS: An in-progress review of the Spacecraft Assembly, Maintenance, and Servicing Study
p 127 N88-15930
Orbital transfer vehicle studies overview
p 150 N88-15931
CRYOGENIC ROCKET PROPELLANTS
Cryogenic Fluid Management Technology Workshop. Volume 1: Presentation material and discussion
[NASA-CP-10001] p 80 N88-15924
STS propellant scavenging systems study. Part 2, volume 2: Cost and WBS/dictionary
[NASA-CR-179278] p 91 N88-17717
CRYOGENICS
Thermal Control Working Group report
p 36 N88-10094
Cryogenic Fluid Management Technology Workshop. Volume 1: Presentation material and discussion
[NASA-CP-10001] p 80 N88-15924
Af cryogenic and fluid management spacecraft technology program p 80 N88-15925
Large capacity cryopropellant orbital storage facility
p 80 N88-15932
CRYSTAL DEFECTS
Materials processing twin experiment
[AIAA PAPER 88-0348] p 163 A88-22255
CRYSTAL GROWTH
Polymer crystal growth facility concept for Space Station laboratory module p 1 A88-15314
The protein crystallization facility (PCF) for Eureca
[IAF PAPER 87-412] p 110 A88-16082
Vapor transport furnace for organic crystals and films
[AIAA PAPER 88-0160] p 113 A88-22113
Advanced protein crystal growth flight hardware for the Space Station
[AIAA PAPER 88-0345] p 3 A88-22253
Materials processing twin experiment
[AIAA PAPER 88-0348] p 63 A88-22255
Prophase A study of a crystallography laboratory for Columbus, executive summary
[ESA-ITT-AO/1-1866/85/F] p 95 N88-10206
Allowable gravity levels for Spacelab, Columbus and EURECA — materials science
[SP-R-88-525-2] p 134 N88-15084
Analysis of low gravity tolerance of model experiments for space station: Preliminary results for directional solidification
[NASA-CR-182657] p 10 N88-19648
CRYSTALLIZATION
The protein crystallization facility (PCF) for Eureca
[IAF PAPER 87-412] p 110 A88-16082
CULTURE TECHNIQUES
Design concepts for bioreactors in space
p 45 N88-17179
CYBERNETICS
Robots - Autonomous space workers
p 64 A88-19968
1987 American Control Conference, 6th, Minneapolis, MN, June 10-12, 1987, Proceedings. Volumes 1, 2, & 3
p 53 A88-27301

D

DAMAGE
Space station integrated wall design and penetration damage control
[NASA-CR-179169] p 25 N88-10070
Natural frequencies and structural integrity assessment of large space structures
[AD-A186139] p 29 N88-15001
DAMAGE ASSESSMENT
Damage detection and location in large space trusses
[AIAA PAPER 88-2461] p 16 A88-31364
DATA ACQUISITION
An approach to design knowledge capture for the space station p 7 A88-21642
OSSA's Telescience concept for the Space Station era
[AIAA PAPER 88-0120] p 112 A88-22083
Space station propulsion technology. Space station propulsion system test bed test plan
[NASA-CR-179201] p 70 N88-10104
Outgassing data for selecting spacecraft materials
[NASA-RP-1124] p 95 N88-10117
Design knowledge capture for the space station
p 9 N88-17219
TDAS: The Thermal Expert System (TEXSYS) data acquisition system p 102 N88-17258
DATA BASE MANAGEMENT SYSTEMS
A data base approach towards Columbus payload accommodation p 99 A88-21257
Third Conference on Artificial Intelligence for Space Applications, part 1
[NASA-CP-2492-Pt-1] p 60 N88-16360
Foundation: Transforming data bases into knowledge bases p 102 N88-16423
Critical issues in NASA information systems
[NASA-CR-182380] p 102 N88-16577
DATA BASES
NASA STD 3000: Man-System Integration Standards - The new space human engineering standards
[AF PAPER 87-550] p 152 A88-16167
ENVIRONET database on vibroacoustics
[AIAA PAPER 88-0010A] p 99 A88-22011
Foundation: Transforming data bases into knowledge bases p 102 N88-16423
DATA LINKS
Interoperability and integration of data relay satellite systems p 78 N88-12134
DATA MANAGEMENT
Automated space power distribution and load management p 67 A88-11660
Space Station ground data management system
p 98 A88-15262
Central processing unit for fault tolerant computing in Columbus p 139 A88-21254
Evolution of data management systems from Spacelab to Columbus
[MBB-UR-E-966-87] p 99 A88-23951
Confidentiality of data — Columbus Polar Platforms
p 146 N88-12136
DATA RETRIEVAL
The economics of satellite retrieval
[AIAA PAPER 88-0843] p 164 A88-27584
DATA STORAGE
An approach to design knowledge capture for the space station p 7 A88-21642
DATA SYSTEMS
From Space Shuttle to Space Station - Graduating from paper to electronic media
[AIAA PAPER 88-0442] p 163 A88-22328
DATA TRANSMISSION
Damming the data stream from space
p 98 A88-19869
A packetized remote visual access data system for Space Station interactive payload operations
p 99 A88-21253
Rapid toxicity detection in water quality control utilizing automated multispecies biomonitoring for permanent space stations p 44 N88-10946
DECISION MAKING
A human performance modelling approach to intelligent decision support systems p 90 N88-17242
Critical issues for establishment of a permanently-occupied lunar base
[AD-A187128] p 107 N88-17567

178

DECONTAMINATION
Materials selection as related to contamination of spacecraft critical surfaces p 95 A89-29965
DECOUPLING
Disturbance and vibration isolation in space stations by means of mechanical decoupling p 11 A89-13932
DEFECTS
Nondestructive construction error detection in large space structures
[AIAA PAPER 89-2460] p 18 A89-31383
DEFENSE PROGRAM
Department of Defense space policy and the development of a global policy for the control of space debris
[IAF PAPER 87-575] p 129 A88-16186
DEGRADATION
High intensity 5 eV O-atom exposure facility for material degradation studies p 96 N89-10947
Degradation mechanisms of materials for large space systems in low Earth orbit
[NASA-CR-181472] p 96 N89-10806
Space environmental effects on polymeric materials
[NASA-CR-182454] p 97 N89-16879
DEGREES OF FREEDOM
Optimal reconfiguration of thermally distorted wire mesh reflectors for large space antennas
[AIAA PAPER 89-2340] p 22 A89-32293
Traction-drive seven degrees-of-freedom telerobot arm: A concept for manipulation in space
[DE87-010895] p 87 N89-10346
DELPHI METHOD (FORECASTING)
Critical issues for establishment of a permanently-occupied lunar base
[AD-A187128] p 107 N89-17567
DENSITY (MASS/VOLUME)
Parametrics of nickel-hydrogen cell design -- for earth orbit vehicles p 75 A88-11912
DENSITY DISTRIBUTION
Aeroassisted orbital transfer vehicle guidance performance in the presence of density dispersions
[AIAA PAPER 88-0302] p 150 A88-22217
DEPLOYMENT
Why mechanisms are critical to spacecraft performance p 90 N88-16737
Space station structures development
[NASA-CR-179261] p 30 N89-16792
Automatic in-orbit payload deployment mechanisms, logistic operations and transport vehicle design compatibilities p 82 N88-19453
Workshop on Technology Development issues for the Large Deployable Reflector (LDR)
[NASA-CP-2407] p 32 N89-20235
DEPOSITION
Astrophysics and the solar nebula
p 118 N89-15355
DESIGN ANALYSIS
Spacecraft technology trends - A view from the past
[IAF PAPER 87-07] p 161 A88-15807
Aeroassisted vehicle design studies for a manned Mars mission
[IAF PAPER 87-433] p 50 A88-16093
An advanced imaging space telescope concept
[IAF PAPER 87-460] p 110 A88-16113
Preliminary design of the Space Station internal thermal control system
[SAE PAPER 871505] p 35 A88-21151
Space Station body mounted radiator design
[SAE PAPER 871507] p 35 A88-21153
An approach to design knowledge capture for the space station p 7 A88-21642
A technique to aid in the design of optimal robots for use in space applications p 85 A88-21648
Vapor transport furnace for organic crystals and films
[AIAA PAPER 88-0160] p 113 A88-22113
Industrial Space Facility
[AIAA PAPER 88-0649] p 3 A88-22484
NASA to evaluate two suit designs for Space Station
p 155 A88-24101
Design and verification of the FLECS test structure -- Flexible ECS-type structure p 54 A88-27779
An efficient multilevel optimization method for engineering design
[AIAA PAPER 88-2226] p 6 A88-32190
Space station integrated wall design and penetration damage control
[NASA-CR-179169] p 25 N88-10070
Assessment of the COFS1/MAST I project
[NASA-CR-181386] p 25 N88-10340
Optimization techniques applied to passive measures for in-orbit spacecraft survivability
[NASA-CR-179216] p 5 N88-12532
Now feedback design methods/stages for large space structures: A multi-criterion optimization approach
p 59 N88-12535
Design and assembly sequence analysis of option 3 for CETP reference space station
[NASA-TM-100503] p 129 N88-13369
Controlled Ecological Life Support Systems (CELSS) conceptual design option study
[NASA-CR-177421] p 44 N88-14625
Maximum entropy/optimal projection design synthesis for decentralized control of large space structures
[AD-A196359] p 29 N88-15003
Space station onboard propulsion system Technology study
[NASA-CR-175233] p 60 N88-15008
Servicer system demonstration plan and capability development
[NASA-CR-179246] p 127 N88-15895
Columbus feasibility studies, Volume 1: Requirements and system concept
[ETN-88-91073] p 146 N88-16799
Study of large solar arrays (SOLA), phase 2B
[BAE SS/1109] p 74 N88-17106
Study of Large Solar Arrays, (SOLA): Phase 2A: Amplifying information to final report (SS/1109)
[BAE SS/1110] p 76 N88-17960
Orbiter transfer vehicle concept definition and system analysis study. Volume 4: Space station accommodations. Revision 1
[NASA-CR-179293] p 150 N88-18609
Orbital transfer vehicle concept definition and system analysis study. Volume 4, Appendix A: Space station accommodations, Revision 1
[NASA-CR-179294] p 150 N88-18610
DESORPTION
Stability of (RA-4) solid amine resin as a function of carbon dioxide absorption and steam desorption cycling
[SAE PAPER 871452] p 40 A88-21112
DETECTION
Techniques for fire detection p 156 N88-12521
DETERIORATION
Space environmental effects on polymeric materials
[NASA-CR-182454] p 97 N88-16879
DIAGNOSIS
Cooperative human-machine fault diagnosis
p 85 A88-21659
A solid phase enzyme-linked immunosorbent assay for the antigenic detection of Legionella pneumophila (serogroup 1): A compliment for the space station diagnostic capability p 157 N88-14868
EUREX D: An expert system for failure diagnosis and recovery in the TCS of the European retrievable carrier EURECA p 146 N88-16385
DIELECTRIC PROPERTIES
Power and charge dissipation from an electrodynamic tether p 73 N89-14969
DIFFUSION
Thermophysical Properties Measurement Facility (TPMF) -- Columbus space station
[ESA-CR(P)-2417] p 9 N89-10981
DIGITAL COMPUTERS
The use of transputers in processing telemetry data
p 98 A88-15303
DIGITAL DATA
Critical issues in NASA information systems
[NASA-CR-182302] p 102 N89-16577
DIGITAL SYSTEMS
Design-to-performance -- of controllers for Space Stations p 2 A89-16295
DIRECTIONAL ANTENNAS
Prospects on future EVA communications
[AIAA PAPER 88-0767] p 76 A88-27542
DIRECTIONAL SOLIDIFICATION (CRYSTALS)
Analysis of low gravity tolerance of model experiments for space station: Preliminary results for directional solidification
[NASA-CR-182657] p 10 N89-19648
DISPERSING
Compatability of dispersion-strengthened platinum with rocket propellants
[NASA-TP-2765] p 79 N89-12538
DISPLAY DEVICES
OMV man/system simulation integration: A preliminary analysis and recommendation
[NASA-CR-182602] p 151 N89-20005
DISTILLATION EQUIPMENT
Vapor compression distiller and membrane technology for water revitalization p 39 A88-17072
DISTRIBUTED PARAMETER SYSTEMS
Distributed systems approach to the identification of flexible structures p 15 A89-22609
Synthesis of the flexible structures of complex systems p 15 A89-27148
Control of distributed parameter systems with spillover using an augmented observer p 16 A89-27377
Convergence properties of modal costs for certain distributed parameter systems p 20 A89-31570
Model order reduction techniques in large space structure applications
[AIAA PAPER 89-2457] p 24 A89-32359
DISTRIBUTED PROCESSING
Use of a distributed microprocessor network for control of the Space Station electrical power system
p 67 A88-11856
Translation and execution of distributed Ada programs - Is it still Ada? p 7 A88-21643
Access control for a safety critical distributed system interface set
[AIAA PAPER 87-3083] p 100 A89-26211
Prototype space station automation system delivered and demonstrated at NASA p 45 N89-16442
DOCUMENTS
From Space Shuttle to Space Station - Graduating from paper to electronic media
[AIAA PAPER 88-0442] p 163 A88-22328
Preliminary analysis of an integrated logistics system for CISSA payloads. Volume 3: CISSA integrated logistics support planning document p 6 N89-19460
DOWNLINKING
Damming the data stream from space
p 98 A88-19803
Simple analysis of Space Station downlinks
p 100 A89-30189
Rapid toxicity detection in water quality control utilizing automated multispecies biomonitoring for permanent space stations p 44 N89-15848
DROPS (LIQUIDS)
Atmospheric science p 5 N89-15357
DRY FRICTION
Investigation of damping from nonlinear sleeve joints of large space structures p 56 A89-31596
DUST
Physics and chemistry p 118 N89-15359
DYNAMIC CHARACTERISTICS
Design-to-performance -- of controllers for Space Stations p 2 A89-16295
Recent advances in dynamics of composite structures p 19 A89-31427
Studies of the structural dynamic behavior of satellite antenna system
[AD-A185528] p 29 N88-14121
DYNAMIC CONTROL
Control techniques for rendezvous and docking p 51 A89-16311
Dynamics and control of a planar truss actuator p 55 A89-31564
Dynamics and control of spacecraft with retargeting flexible antennas
[AIAA PAPER 90-1014] p 57 A89-32341
DYNAMIC LOADS
Control-augmented structural synthesis
[AIAA PAPER 89-1214] p 55 A89-28043
DYNAMIC MODELS
Performance characteristics of moving belt radiators -- for spacecraft applications p 33 A89-12006
On control of tethered satellite systems
p 110 A89-16294
Modelling and simulation of distributed flexibility in a spaceborne manipulator p 63 A89-16309
Large space structures testing
[AAS PAPER 87-036] p 13 A89-16996
Dynamics and control of the Tethered Satellite System in the presence of offsets p 112 A89-20036
Tether Dynamics Simulation Workshop summary
[AIAA PAPER 89-0531] p 113 A89-22397
Integrated control of large flexible structures
p 16 A89-25474
Space Station - A focus for the development of structural dynamics scale model technology for large flexible space structures
[AIAA PAPER 88-2483] p 10 A89-31302
An investigation of the damping phenomena in wire rope isolators p 21 A89-31597
Mode shape identification and orthogonalization
[AIAA PAPER 89-2354] p 23 A89-32294
A comparative survey of mathematical models for dynamic simulation of in-orbit manipulation operations
p 148 N89-19533
DYNAMIC RESPONSE
Studies of the structural dynamic behavior of satellite antenna system
[AD-A185528] p 29 N88-14121
Kinetic isolation tether experiment
[NASA-CR-182458] p 120 N89-16810
DYNAMIC STRUCTURAL ANALYSIS
Recent advances in structural dynamics of large space structures
[IAF PAPER 87-51] p 11 A88-15936
Numerical and numerical-analytical interfaces in structural thermal-dynamic interactive problems
[IAF PAPER 87-302] p 49 A88-16020
Application of perturbation techniques to flexible multibody system dynamics p 14 A89-27608

Some experiences with the Eigensystem Realization Algorithm p 17 A89-29815
Space Station - A focus for the development of structural dynamics scale model technology for large flexible space structures
[AIAA PAPER 89-2483] p 19 A89-31392
Modal coupling of structures with complex storage moduli p 20 A89-31580
Fractional derivatives in the description of damping materials and phenomena p 20 A89-31589
Very high damping in large space structures p 20 A89-31594
Investigation of damping from nonlinear sleeve joints of large space structures p 56 A89-31596
Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Parts 1, 2, & 3 p 21 A89-32176
Analytical and experimental investigations for satellite antenna deployment mechanisms
[AIAA PAPER 88-2225] p 76 A89-32189
Dynamic characterization of structures by pulse probing and deconvolution
[AIAA PAPER 88-2230] p 21 A89-32193
A finite element method for time varying geometry in multibody structures
[AIAA PAPER 88-2234] p 21 A89-32197
A general approach to modal analysis for time varying systems
[AIAA PAPER 88-2356] p 23 A89-32296
Structural model verification with LQG theory -- Linear Quadratic Optimization
[AIAA PAPER 88-2360] p 23 A89-32300
Three parallel computation methods for structural vibration analysis
[AIAA PAPER 88-2391] p 24 A89-32323
Transient response of joint dominated space structures - A new linearization technique
[AIAA PAPER 88-2392] p 24 A89-32325
Survey of parameter estimation methods in experimental modal analysis p 24 A89-32710
Efficient placement of structural dynamics sensors on the space station
[NASA-CR-172015] p 25 N89-10103
A DMAP for updating dynamic mathematical models with measured data
[NLR-MP-86027-U] p 26 N89-10387
Recent advances in structural dynamics of large space structures
[NASA TM-100519] p 26 N89-10967
Structural Assembly Demonstration Experiment (SADE)
[NASA-CR-179205] p 26 N89-10968
Viscous damped space structure for reduced jitter p 28 N89-13523
Studies of the structural dynamic behavior of satellite antenna system
[AD-A190526] p 28 N89-14121
Preliminary investigation of stability of a tri-stiffened slender strut
[NASA-TM-4004] p 31 N89-19568

DYNAMIC TESTS

Design and analysis of passively damped large space structures p 56 A89-31574
Large space structure damping treatment performance - Analytic and test results p 20 A89-31586
Cost effective development of a national test bed
[NASA-TM-100321] p 31 N89-19585

DYNAMICAL SYSTEMS

The distributed AI system for the dynamic allocation and management of power (DAISY-DAMP) testbed p 64 A89-21639
Solar thermodynamic power systems in space p 72 A89-28150
Dynamics of large constrained flexible structures p 16 A89-28509
Estimation and identification of nonlinear dynamic systems
[AIAA PAPER 88-2271] p 57 A89-32027
A general approach to modal analysis for time-varying systems
[AIAA PAPER 88-2356] p 23 A89-32296
Model order reduction techniques in large space structure applications
[AIAA PAPER 88-2467] p 24 A89-32359
Dynamics of spacecraft control laboratory experiment (SCOLE) slew maneuvers
[NASA-CR-4098] p 57 N89-10082
Approaches and possible improvements in the area of multibody dynamics modeling
[NASA-CR-179227] p 28 N89-14067
Motion simulation for in-orbit operations p 62 N89-19514
Analysis of a rotating advanced-technology space station for the year 2025
[NASA-CR-178345] p 107 N89-19080

E

EARTH ATMOSPHERE

Solar power satellites p 72 A89-17023
Remote sensing Earth's surface and atmosphere. Proceedings of Workshop II and the Topical Meeting of the 26th COSPAR Plenary Meeting, Toulouse, France, June 30-July 11, 1988 p 111 A89-17026
Applications of tethered satellites to some problems of terrestrial physics
[AIAA PAPER 89-0663] p 114 A89-22515
Reconstruction of the vertical atmospheric temperature profile on the basis of refraction measurements from the Salyut-7 orbital station p 131 A89-23930

EARTH IONOSPHERE

Numerical analysis of interaction of a high-voltage solar array with ionospheric plasma p 72 A89-27999
The combined release and radiation effects satellite, a joint NASA-DOD program p 131 N89-10951

EARTH MAGNETOSPHERE

Applications of tethered satellites to some problems of terrestrial physics
[AIAA PAPER 89-0663] p 114 A89-22515

EARTH OBSERVATIONS (FROM SPACE)

Geostationary earth observations. Platform operations from the Space Station
[IAF PAPER 87-10] p 109 A89-15614
Operational utilization of the polar platforms
[IAF PAPER 87-13] p 109 A89-15662
Earth observation from the Space Station p 112 A89-21067
Earth observation and the Space Station p 112 A89-21568
SPOT 1 - Earth observing satellite p 3 A89-26166
Japan takes charge p 143 A89-27952
Study of a payload for Columbus Polar Platform Earth observation demonstration mission, executive summary
[ESA-CNUF) 2412] p 116 N89-10679
Payload configurations and serviceability -- Columbus Polar Platforms p 117 N89-12133
Legal protection of the Polar Platform's users p 145 N89-12135
Proceedings of the ESA Workshop on Co-Orbiting Platform Elements (COPE)
[ESA-SP-1093] p 146 N89-16777
An overview of the current Earth observation programs (Europe, USA, and Japan) p 167 N89-16778
Polar platform element of Space Station. Mission objectives, European priorities, candidate instrumentation and selection procedure p 119 N89-16779
Tethers. An outline of a new concept for Earth observation p 120 N89-16781
Microgravity payloads and missions for Space Station. Some issues affecting compatibility with other payloads p 120 N89-16783

EARTH ORBITAL ENVIRONMENTS

Electrical power system for low earth orbit spacecraft applications p 65 A89-11817
The space based OTV and the establishment of the next launch site
[IAF PAPER 87-196] p 160 A89-15933
Solar thermal OTVs in comparison with electrical and chemical propulsion systems
[IAF PAPER 87-197] p 77 A89-15934
Optimal trajectories for aeroassisted, noncoplanar orbital transfer II - LEO-to-LEO transfer
[IAF PAPER 87-329] p 49 A89-16024
Angular momentum management for LEO platforms
[IAF PAPER 87-349] p 69 A89-16039
Stability analysis for alternative force control schemes as applied to remote space teleoperation
[AAS PAPER 87-043] p 51 A89-16098
Artificial space debris -- Book p 130 A89-17944
Oxidation-resistant reflective surfaces for solar dynamic power generation in near earth orbit p 70 A89-18523
Future U-orbit technology demonstrations p 14 A89-21521
Shuttle experiments to measure the optical environments surrounding large space structures
[AIAA PAPER 89-0432] p 14 A89-22521
Observations of ions generated on or near satellite surfaces
[AIAA PAPER 89-0434] p 130 A89-22523
Large deployable reflector thermal characteristics in low earth orbits
[AIAA PAPER 89-0471] p 36 A89-22547
Solar dynamic heat receiver thermal characteristics in low earth orbit
[AIAA PAPER 89-0472] p 71 A89-22548
True energy atmospheric simulator for low earth orbit spacecraft
[AIAA PAPER 88-0727] p 3 A89-22549
Dynamics of earth-orbiting flexible satellites with multibody components p 52 A89-22605
Particle-bed reactor propulsion vehicle performance and characteristics as an orbital transfer rocket p 79 A89-22707
Orbital systems p 143 A89-26170
High-energy orbit refueling for orbital transfer vehicles p 155 A89-27667
Steady state micro-g environment on Space Station
[AIAA PAPER 89-2462] p 4 A89-31385
Response of composite materials to the Space Station orbit environment
[AIAA PAPER 88-2476] p 95 A89-31390

EARTH ORBITS

GEO platform servicing - Technology solutions
[IAF PAPER 87-06] p 122 A89-15808
The combined release and radiation effects satellite, a joint NASA-DOD program p 131 N89-10951
Spacecraft surface exposure to atomic oxygen in low Earth orbit p 96 N89-11715
Low Earth orbit environmental effects on the space station photovoltaic power generation systems
[NASA-TM-100230] p 73 N89-12429
Investigation of design concepts for large space structures to support military applications
[AD-A190398] p 29 N89-15300
A lunar transportation system
[NASA-CR-182561] p 107 N89-19379
State-of-the-art technologies for construction in space. A review
[AD-A189812] p 31 N89-19483

EARTH RESOURCES

Critical issues in NASA information systems
[NASA-CR-182380] p 102 N89-16577

EARTH ROTATION

Effect of rotating earth for analysis of aeroassisted orbital transfer vehicles p 3 A89-26257

EARTH SURFACE

Remote sensing Earth's surface and atmosphere. Proceedings of Workshop II and the Topical Meeting of the 26th COSPAR Plenary Meeting, Toulouse, France, June 30-July 11, 1988 p 111 A89-17026

ECHOCARDIOGRAPHY

Cardiovascular adaptation to zero-g during a long term flight (237 days) on board the Salyut 7 Soviet space station (1984) p 159 N89-19921

ECONOMIC ANALYSIS

Definition and economic evaluation of Space Solar Power Systems (SSPS), part 1
[LR 5677 164 (V1987)] p 73 N89-16189
Definition and economic evaluation of Space Solar Power Systems (SSPS), part 2
[LR 5677 164 (V1987)] p 73 N89-16190

ECONOMIC FACTORS

The economics of satellite retrieval
[AIAA PAPER 88-0942] p 104 A89-27584
Commercial perspective of an imaging spectrometer development program p 105 N89-12139
Review of commercial spacecraft. Recovery and repair experiences, implications for future spacecraft designs and operations p 128 N89-19528

ECONOMY

Advancing automation and robotics technology for the space station and for the US economy. Submitted to the United States Congress October 1, 1987
[NASA-TM-100777] p 60 N89-15816
Advancing automation and robotics technology for the space station and for the US economy. Submitted to the United States Congress October 1, 1988
[NASA-TM-89190] p 60 N89-15818

EDUCATION

ESA Bulletin No. 25
[ISSN-0376-4265] p 146 N89-16787

EIGENVALUES

Some experiences with the Eigensystem Realization Algorithm p 17 A89-29815
The component-mode method in a parallel computer environment
[AIAA PAPER 88-2436] p 6 A89-32355
Simultaneous structural and control optimization via linear quadratic regulator eigenstructure assignment p 28 N89-13622

EIGENVECTORS

New feedback design methodologies for large space structures. A multi-criterion optimization approach p 59 N89-12535

ELASTIC DAMPING

Fractional derivatives in the description of damping materials and phenomena p 20 A89-31589

ELASTIC DEFORMATION

Application of perturbation techniques to flexible multibody system dynamics p 14 A89-20908
Optimal reconfiguration of thermally distorted wire mesh reflectors for large space antennas
[AIAA PAPER 88-2340] p 22 A89-32040

ELASTIC PROPERTIES

Monitoring elastic stiffness degradation in graphite/epoxy composites p 14 A89-18173

180

Natural control of flexible space structures
p 58 N88-12534

ELECTRIC CONTACTS
Plasma contactors for use with electrodynamic tethers for power generation
[IAF PAPER 87-251] p 69 A88-15970

ELECTRIC CURRENT
Electrical current flow across the TSS - The core equipment and other related technical issues
[IAF PAPER 87-252] p 109 A88-15971

ELECTRIC DISCHARGES
Discharge phenomena -- spacecraft
p 132 N88-11723
Discharge prevention of geosynchronous orbit conductive thermal control materials and grounding systems
p 76 N88-11732
Power and charge dissipation from an electrodynamic tether
p 73 N88-14869
Atmospheric science
p 5 N88-15357

ELECTRIC FILTERS
Design techniques for 20K Hz power converters
p 66 A88-11822

ELECTRIC GENERATORS
IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volumes 1, 2, 3, & 4
p 63 A88-11776
Laser solar power satellites - A case study in technology forecasting
p 68 A88-15492

ELECTRIC POWER
Plasmoid power station
[IAF PAPER 87-250] p 69 A88-15969

ELECTRIC POWER SUPPLIES
Space Station electric power system requirements and design
p 63 A88-11782
Computer modeling and simulation of a 20kHz ac distribution system for Space Station
p 66 A88-11827
Electrical power for Columbus - An important cross-element task
p 140 A88-21560
The distributed AI system for the dynamic allocation and management of power (DAISY-DAMP) testbed
p 64 A88-21638
Plasma contactors for use with electrodynamic tethers for power generation
[NASA-CR-182424] p 73 N88-16547

ELECTRIC POWER TRANSMISSION
Comparative study of cable construction for 20 kHz power distribution
p 66 A88-11831
The ac power system testbed
[NASA-CR-179389] p 72 N88-11948

ELECTRICAL FAULTS
Incipient fault detection and power system protection for spaceborne systems
p 66 A88-11826
Expert system for fault detection and recovery for a space based power management and distribution system
p 68 A88-11882

ELECTRICAL INSULATION
Discharge prevention of geosynchronous orbit conductive thermal control materials and grounding systems
p 76 N88-11732

ELECTRICAL RESISTIVITY
External surface charging mechanisms -- spacecraft
p 132 N88-11719

ELECTROCHEMICAL CELLS
Electrochemically regenerable carbon dioxide/moisture control technology for an Advanced Extravehicular Mobility Unit
[SAE PAPER 871470] p 41 A88-21126

ELECTROCHEMISTRY
Electrochemical processing of solid waste
[NASA-CR-182413] p 157 N88-15852

ELECTRODYNAMICS
The tethered satellite electrodynamics experiment project
[AIAA PAPER 88-0690] p 114 A88-22516
Electrodynamic tether system study
[NASA-CR-172024] p 117 N88-11737
Tethers in space handbook
[NASA-CR-181371] p 118 N88-14123
Power and charge dissipation from an electrodynamic tether
p 73 N88-14869
Plasma contactors for use with electodynamic tethers for power generation
[NASA-CR-182424] p 73 N88-16547

ELECTROLYSIS
Static feed electrolyzer technology advancement for space application
[SAE PAPER 871450] p 40 A88-21110
High pressure water electrolysis for the Space Station
[SAE PAPER 871473] p 41 A88-21128
Electrochemical processing of solid waste
[NASA-CR-182413] p 157 N88-15852

ELECTROLYTIC CELLS
Performance evaluation of SPE electrolyzer for Space Station life support
[SAE PAPER 871451] p 40 A88-21111

ELECTROMAGNETIC COMPATIBILITY
Model of space platform electromagnetic (EMC) configuration
[ESA-CR(P)-2500] p 9 N88-16809

ELECTROMAGNETIC INTERFERENCE
EMC and power quality standards for 20-kHz power distribution
p 66 A88-11830

ELECTROMAGNETIC PUMPS
An evaluation of heat pipe radiators incorporating pumped liquid return
p 33 A88-11810

ELECTROMAGNETIC RADIATION
Power and charge dissipation from an electrodynamic tether
p 73 N88-14869

ELECTROMAGNETISM
Stability of the steady motions of an electromagnetic tether system in orbit
p 107 A88-11234

ELECTRON BEAMS
The effect of photoelectrons on boom-satellite potential differences during electron beam ejection
[AD-A190390] p 75 A88-20350

ELECTRON EMISSION
The effect of photoelectrons on boom-satellite potential differences during electron beam ejection
[AD-A190390] p 75 A88-20350

ELECTRONIC EQUIPMENT
Estimating payload internal temperatures and radiator size for multimegawatt space platforms
[DE88-000244] p 37 N88-11738

ELECTROPHORESIS
Use of hydrophilic polymer coatings for control of electroosmosis and protein adsorption
p 113 N88-15620

ELECTROSTATIC PROBES
Electrostatic analyzers design for space investigations
p 121 A88-29013

ELECTROSTATICS
Analysis of geophysical data bases and models for spacecraft interactions
[AD-A184809] p 133 N88-13275

ELEVATORS (LIFTS)
Analytical investigation of the dynamics of tethered constellations in Earth orbit (phase 2)
[NASA-CR-179218] p 117 N88-12533
Tether Elevator Crawler Systems (TECS)
p 119 N88-15631

ELLIPTICAL ORBITS
Optimal time free nodal transfers between elliptical orbits
[IAF PAPER 87-325] p 78 A88-16021

EMERGENCIES
The determination of nutritional requirements for Safe Haven Food Supply System (emergency rations of foods)
p 45 N88-14856

END EFFECTORS
The ESA-Fokker service end-effector subsystem: A robotic/man-compatible servicing approach
p 92 N88-19502

END-TO-END DATA SYSTEMS
Telerobotics and orbital laboratories - An end-to-end analysis and demonstration
[IAF PAPER 87-27] p 93 A88-15919

ENERGY CONVERSION
IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volumes 1, 2, 3, & 4
p 63 A88-11776

ENERGY CONVERSION EFFICIENCY
Ross-Stirling engine - A high performance dynamic space power system
p 63 A88-11797
Impact of thermal energy storage properties on solar dynamic space power conversion system mass
p 64 A88-11805
Space solar cell research - Problems and potential
p 70 A88-21605
Optimization of the parameters of a solar photoelectric system exposed to cosmic rays
p 72 A88-26250
The high performance solar array GSR3
[SNIAS-872-422-108] p 73 N88-13914

ENERGY DISSIPATION
Control for energy dissipation in structures
[AIAA PAPER 88-2272] p 22 A88-32029
Power and charge dissipation from an electrodynamic tether
p 73 N88-14869

ENERGY POLICY
Satellite power systems under consideration by the United Nations
p 74 N88-16773

ENERGY REQUIREMENTS
Allocating energy to experiments on the Space Station
p 66 A88-11828
Automated load management for spacecraft power systems
p 67 A88-11863
Power requirements for an orbiting space farm
[IAF PAPER 87-242] p 70 A88-15989

ENERGY SPECTRA
Determination of cosmic-ray characteristics on Salyut-7
p 131 A88-26349

ENERGY STORAGE
Electrodynamic tether system study
[NASA-CR-172024] p 117 N88-11737

ENERGY TECHNOLOGY
Photovoltaics for commercial solar power applications; Proceedings of the Meeting, Cambridge, MA, Sept. 18, 19, 1986
[SPIE-706] p 70 A88-21801
Satellite power systems under consideration by the United Nations
p 74 N88-16773

ENGINE DESIGN
Ross-Stirling engine - A high performance dynamic space power system
p 63 A88-11797

ENGINE TESTS
A life test of a 22-Newton (5-lbf) hydrazine rocket
[NASA-TM-100232] p 79 N88-11750
Space station propulsion technology
[NASA-CR-179260] p 80 N88-15835

ENTROPY
Maximum entropy/optimal projection design synthesis for decentralized control of large space structures
[AD-A186359] p 29 N88-15003

ENVIRONMENT EFFECTS
Environmental constraints for Polar Platform design
[IAF PAPER 87-09] p 108 A88-15809
Solar power satellites
p 70 A88-17023

ENVIRONMENT POLLUTION
Space station contamination considerations
p 131 N88-10959

ENVIRONMENT SIMULATORS
Thermal environment simulator for vacuum testing of large spacecraft
p 36 A88-25979

ENVIRONMENTAL CONTROL
Environmental control and life support systems analyses for a Space Station life sciences animal experiment
[SAE PAPER 871417] p 39 A88-21081
A computer aided engineering tool for ECLS systems
[SAE PAPER 871423] p 98 A88-21087
G189 computer program: modeling of environmental control and life support systems for the Space Station
[SAE PAPER 871427] p 39 A88-21090
Environmental control and life support system for Japanese Experiment Module
[SAE PAPER 871429] p 39 A88-21092
Columbus ECLSS
[SAE PAPER 871430] p 139 A88-21093
Environmental control and life support system requirements and technology needs for advanced manned space missions
[SAE PAPER 871433] p 39 A88-21096
The Space Station air revitalization subsystem design concept
[SAE PAPER 871448] p 40 A88-21108
A smoke removal unit
[SAE PAPER 871449] p 153 A88-21109
Static feed electrolyzer technology advancement for space application
[SAE PAPER 871450] p 40 A88-21110
Environmental control and life support testing at the Marshall Space Flight Center
[SAE PAPER 871453] p 40 A88-21113
Initial results of integrated testing of a regenerative ECLSS at MSFC
[SAE PAPER 871454] p 41 A88-21114
An experimental study of the Bosch and the Sabatier CO2 reduction processes
[SAE PAPER 871517] p 43 A88-21162
Large space systems environmental entanglements
[AIAA PAPER 88-0386] p 14 A88-22296
Development of a graphical display on the DMS test bed
p 101 N88-14864
Space station accommodations for life sciences research facilities. Phase 1: Conceptual design and programmatics studies for Missions SAAX0307, SAAX0302 and the transition from SAAX0307 to SAAX0302. Volume 2: Study results
[NASA-CR-179294] p 104 N89-19829
Prototype space station automation system delivered and demonstrated at NASA
p 45 N89-19442

ENVIRONMENTAL TESTS
Response of composite materials to the Space Station orbit environment
[AIAA PAPER 88-2479] p 95 A88-31390

ENZYME ACTIVITY
A solid phase enzyme-linked immunosorbent assay for the antigenic detection of Legionella pneumophila (serogroup 1): A compliment for the space station diagnostic capability
p 157 N88-14968

EPOXY MATRIX COMPOSITES
Oxidation and protection of fiberglass-epoxy composite masts for photovoltaic arrays in the low Earth orbital environment
[NASA-TM-100839] p 97 N89-18734

EPOXY RESINS
High temperature resistant corn/starch modified epoxies
p 95 A88-29585

EQUATIONS OF MOTION
Stability of the steady motions of an electromagnetic tether system in orbit p 107 A88-11234
Motion perturbations of a dumbbell in a central Newtonian force field p 67 A88-11235
Dynamics of orbiting debris clouds and the resulting collision hazard to spacecraft
(IAF PAPER 87-571) p 129 A88-16183
Formulation of rigid multibody systems in space p 14 A88-21221
Dynamics of large constrained flexible structures p 16 A88-28509
Electrostatic analyzers design for space investigation p 131 A88-29623
Natural control of flexible space structures p 58 N88-12534
Dynamics formulations for the real-time simulation of constrained motion p 60 N88-14872
EQUATIONS OF STATE
Dynamics of large constrained flexible structures p 16 A88-28509
EQUIPMENT SPECIFICATIONS
Advanced space solar dynamic power systems beyond IOC Space Station p 64 A88-11798
Servicer system demonstration plan and capability development
(NASA-CR-179246) p 127 N88-15905
EROSION
Spacecraft surface exposure to atomic oxygen in low Earth orbit p 96 N88-11715
ERROR ANALYSIS
A model-free method for mass spectrometer response correction — for oxygen consumption and cardiac output calculation p 111 A88-19803
ERROR CORRECTING CODES
Expert system for fault detection and recovery for a space based power management and distribution system p 68 A88-11882
ERROR DETECTION CODES
Cooperating expert systems for power systems — Space Station resource allocation p 68 A88-11801
Expert system for fault detection and recovery for a space based power management and distribution system p 68 A88-11882
Processes in construction of failure management expert systems from device design information p 86 A88-24230
ERRORS
Space station software reliability analysis based on failures observed during testing at the multisystem integration facility p 101 N88-14884
ESA SATELLITES
The Eureca space platform p 143 A88-29856
Report on the scientific satellites of the European Space Agency
(ESA-SP-1090) p 116 N88-10081
ESA SPACECRAFT
Man tended free flyer interior equipment for manned and automated operation
(IAF PAPER 87-75) p 136 A88-15850
ESCHERICHIA
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment p 145 N88-12917
ESTIMATES
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 1: Executive summary p 6 N88-10678
ETHERS
Space environmental effects on polymeric materials
(NASA-CR-182454) p 97 N88-16679
EULER-LAGRANGE EQUATION
Electrostatic analyzers design for space investigation p 131 A88-29623
EURECA (ESA)
Enhanced Eureca configuration/operations p 134 A88-15295
EURECA - An expert system for the management of experiments to be performed on a free-flying platform
(IAF PAPER 87-29) p 135 A88-15821
Development of a cooperative operational rendezvous plan for Eureca and other manoeuvring Shuttle payloads
(IAF PAPER 87-218) p 103 A(9-15946
The protein crystallization facility (PCF) for Eureca
(IAF PAPER 87-410) p 110 A88-16082
Design and development of the life support subsystem of a laboratory model of the Botany Facility
(SAE PAPER 871519) p 43 A89-21164
Eureca - European user-friendly retrievable carrier p 139 A88-21251
European retrievable carrier Eureca servicing by Hermes p 139 A88-21256
The Eureca concept and its importance in preparing the Columbus Programme p 140 A88-21524
Evolution of data management systems from Spacelab to Columbus
(MBB-UR-E-969-87) p 99 A88-23981
The Eureca space platform p 143 A88-29856
Allowable gravity levels for Spacelab, Columbus and EURECA — materials science
(BF-R-66.525-2) p 132 N88-15084
External payload servicing: Operational requirements and technology p 129 N88-19541
Exobiology and botany facilities for EURECA p 148 N88-19898
Microgravity User Support Center (MUSC) for EURECA, Spacelab and Columbus missions p 149 N88-19947
EUROPEAN COMMUNICATIONS SATELLITE
Design and verification of the FLEECS test structure — Flexible ECS-type structure p 54 A88-27779
EUROPEAN SPACE AGENCY
Advanced materials for ESA spacecraft p 133 A88-13569
The use of advanced materials in space structure applications
(IAF PAPER 87-305) p 94 A88-16096
Future in-orbit technology demonstrations p 14 A88-21521
ESA Bulletin No. 25
(ISSN 0376-4265) p 146 N88-16767
The European Space Agency's role in life sciences and research in space p 148 N88-19894
Life sciences in the framework of the ESA microgravity program and future flight opportunities p 149 N88-19895
EUROPEAN SPACE PROGRAMS
Columbus takes shape - Europe's Space Station approaches decision time p 132 A88-10878
Legal problems in the construction of space stations p 133 A88-13449
Future European ground segment — to support earth observation satellites p 133 A88-15279
Rendezvous and docking technology for future European missions p 46 A88-15280
Columbus Space Segment definition p 133 A88-15293
Development of the resource module for the European space station programme Columbus p 134 A88-15294
The Columbus system baseline and interfaces p 134 A88-15297
The in-orbit technology demonstration programme of the European Space Agency
(IAF PAPER 87-03) p 135 A88-15803
European Polar Platform operations and logistics
(IAF PAPER 87-15) p 135 A88-15812
Logistics flow for Columbus MTFF
(IAF PAPER 87-39) p 123 A88-15829
European EVA requirements and space suit design
(IAF PAPER 87-41) p 152 A88-15830
Columbus: present programme status
(IAF PAPER 87-62) p 135 A88-15841
Evolution towards an autonomous European manned space infrastructure
(IAF PAPER 87-67) p 136 A88-15846
Possibilities for a European evolutionary space infrastructure
(IAF PAPER 87-68) p 105 A88-15847
Long-term evolution toward European manned spaceflight
(IAF PAPER 87-78) p 136 A88-15853
Preparation of Space Station/Columbus utilization
(IAF PAPER 87-95) p 137 A88-15866
Interim Flight Opportunity (IFO) — small European space experiment platform
(IAF PAPER 87-379) p 138 A88-16054
Control aspects of a European space manipulator system p 93 A88-16313
The Columbus programme - European steps towards the considered development of near-earth space p 138 A88-19635
EVA for a European Scenario
(SAE PAPER 871432) p 123 A88-21095
The Columbus Attached Pressurized Module - System and management aspects of international cooperation p 139 A88-21252
Strengthening graphite-epoxy composites p 95 A88-21534
The Columbus Programme p 140 A88-21535
Principles of operations cooperation between the United States and Europe p 141 A88-21564
Future European ground segment — for Columbus Space Station
(MBB-UR-E-976-87) p 142 A88-23980
Orbital systems p 143 A88-28170
The space life sciences research and application in Europe p 143 A88-29108
Columbus preparatory program: Payload element study on a technology demonstration mission, executive summary
(CS-RP-AI-018) p 145 N88-10580
Report on the scientific satellites of the European Space Agency
(ESA-SP-1090) p 116 N88-10081
Preliminary study of a gravitational biology facility for Columbus, executive summary
(MATRA-EPT-AS/VT209/255/INT) p 145 N88-10205
Robotic sensors and actuators for a service manipulator system. Volume 1: Executive summary
(MATRA-EPT-DT/VT167/120) p 97 N88-10041
Robotic sensors and actuators for a service manipulator system. Volume 2: Service Manipulator System (SMS) handbook
(MATRA-EPT-DT/VT167/227) p 97 N88-10042
Robotic sensors and actuators for a service manipulator system. Volume 3, phase A report and program plan
(MATRA-EPT-DT/VT167/228) p 97 N88-10043
Space station based interferometry p 116 N88-10629
Mechanical design of the ac bracket package for the PETE experiment
(IFSI-87-4) p 145 N88-13379
ESA Bulletin No. 25
(ISSN 0376-4265) p 146 N88-16767
Proceedings of the ESA Workshop on Co-Orbiting Platform Elements (COPE)
(ESA-SP-1093) p 146 N88-16777
An overview of the current Earth observation programs (Europe, USA, and Japan) p 167 N88-16778
The Columbus program, an overview p 146 N88-16784
Coorbiting Platform Utilization Study (CPLUS), executive summary — Columbus
(SN-RP-4000-DOC-8609-95/F) p 120 N88-16798
Study on long term evolution towards European manned space flight. Volume 1: Executive summary
(MBB-RA3-004-87-VOL-1) p 167 N88-17989
Columbus feasibility studies. Volume 4: Integration, test, and operations
(ETN-88-90576) p 167 N88-18614
Assembly and servicing of a European Space Station p 147 N88-19492
Utilization of SMS and EVA for the servicing of European Space Station p 147 N88-19500
The ESA/Fokker service end-effector subsystem: A robotic/man-compatible servicing approach p 92 N88-19502
Robotic intelligence issues for space manipulator monitoring/control programming p 92 N88-19504
Robotics servicing experiment — European space programs p 93 N88-19529
Definition of the EUROSIM simulation subsystem p 148 N88-19532
Man-tended options for European space robotics p 94 N88-19538
The European Space Agency's role in life sciences and research in space p 148 N88-19894
Life sciences in the framework of the ESA microgravity program and future flight opportunities p 149 N88-19895
European activities in exobiological research in space p 150 N88-19929
EUTECTIC ALLOYS
Solar receiver for the Space Station Brayton engine
(ASME PAPER 87-GT-252) p 62 A88-11134
EVALUATION
Controlled Ecological Life Support Systems (CELSS) physiochemical waste management systems evaluation
(NASA-CR-177402) p 45 N88-14626
EVAPORATIVE COOLING
Advanced radiator concepts utilizing honeycomb panel heat pipes
(NASA-CR-172917) p 97 N88-12747
EXOBIOLOGY
One mission on board the MIR Space Station - The French-Soviet project Aragatz
(IAF PAPER 87-90) p 137 A88-15867
Space biogel's inflight safety considerations
(IAF PAPER 87-570) p 153 A88-16182
The opportunities for space biology research on the Space Station p 153 A88-20282
Biotechnology opportunities on Space Station
(SAE PAPER 871468) p 154 A88-21124
Design and development of the life support subsystem of a laboratory model of the Botany Facility
(SAE PAPER 871519) p 43 A88-21164
Space life sciences in Japan p 154 A88-29107
The opportunities for space biology research on the Space Station p 155 A88-29134
Need, utilization, and configuration of a large, multi-G centrifuge on the Space Station p 156 A88-29140

182

Preliminary study of a gravitational biology facility for Columbus, executive summary
(MATRA-ESPT-RS-VT-2030-255/87) p 145 N88-10205
Exobiology and life sciences p 158 N88-15358
JPRS report: Science and technology. USSR: Space (JPRS-USP-87-036) p 166 N88-16063
Exobiology and battery facilities for EURECA
p 168 N88-19858
European activities in exobiological research on space
p 159 N88-19929
Medilab: A project of a medical laboratory in space
p 159 N88-19946
Artibiotic activity in space: results and hypotheses
p 159 N88-19957

EXPANDABLE STRUCTURES
Roll-out fin expandable space radiator concept
p 36 A88-30527
Assessment of the COFS-1/MAST I project
(NASA-CR-181366) p 25 N88-10340

EXPENDABLE STAGES (SPACECRAFT)
Orbital systems p 143 A88-29170
Communications satellite systems operations with the space station. Volume 3: Supplementary technical report
(NASA-CR-180675) p 77 N88-16758
Assessment of mixed fleet potential for space station launch and assembly
(NASA-TM-100552) p 107 N88-19609

EXPERIMENT DESIGN
Support of life science research in space by the DFVLR Microgravity User Support Center (MUSC)
(IAF PAPER 87-549) p 152 A88-19107
Experiments to ensure Space Station fire safety - A challenge
(AIAA PAPER 88-0540) p 155 A88-22401
Preliminary study of a containerless processing facility for Columbus, executive summary
(ESA-ITALO-1-1834/85/F) p 96 N88-10203
Control design challenges of large space systems and spacecraft control laboratory experiment (SCOLE)
(NASA-CR-179392) p 58 N88-11705
Attainable gravity levels for Spacelab, Columbus and EURECA -- materials science
(IF A-66.525.2) p 132 N88-15080
Tether Elevator Crawler Systems (TECS)
p 119 N88-19601
Microgravity payloads and missions for Space Station. Some issues affecting compatibility with other payloads
p 120 N88-19783
The NORSTAR Program: Space shuttle to space station
p 167 N88-17710
Promising concepts for ground-to-orbit experiment teleoperation -- CobriBox
p 93 N88-19519
Implications of shiftwork in space for human physiology experiments
p 129 N88-19942
Animal research on the Space Station
p 119 N88-19984

EXPERIMENTATION
Dynamics of spacecraft control laboratory experiment (SCOLE) slew maneuvers
(NASA-CR-4096) p 57 N88-10082

EXPERT SYSTEMS
Application of advanced automation techniques in the Space Station electrical power system
p 75 A88-11805
Cooperating expert systems for power systems -- Space Station resource allocation
p 68 A88-11881
Expert system for fault detection and recovery for a space based power management and distribution system
p 68 A88-11882
CAMERA: Expert System for Space Station communications and tracking system management -- Control and Monitor Equipment Resource Allocation
p 75 A88-11895
EURECA - An expert system for the management of experiments to be performed on a free-flying platform
(IAF PAPER 87-29) p 155 A88-15821
Applicability of A.I. techniques to the Space Station, a study case: Development of an expert system for on-board fault management
(IAF PAPER 87-30) p 93 A88-15822
Cooperating expert systems for Space Station power distribution management
p 71 A88-21633
Controlling real-time processes on the Space Station with expert systems
p 84 A88-21634
Use of communicating expert systems in fault diagnosis for Space Station applications
p 63 A88-21635
PLANI IT - Knowledge-based mission sequencing
p 7 A88-21644
Implementation of expert system technology on the Space Station
p 99 A88-21654
Impact of intelligent systems on Space Station man-machine interface (MMI) design
p 85 A88-21655
Cooperative human-machine fault diagnosis
p 85 A88-21659
Processes in construction of failure management expert systems from device design information
p 86 A88-24230
Potential applications of expert systems and operations research to space station logistics functions
(NASA-CR-180670) p 87 N88-12162
National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 2
(NASA-CR-172509-VOL-2) p 180 N88-14010
Dynamics, control and sensor issues pertinent to robotic hands for the EVA retriever system
p 65 N88-14515
Expert system study for spacecraft management
(TI-2630-ISS-1) p 101 N88-15202
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems
(NASA-TM-89705) p 86 N88-15497
Third Conference on Artificial Intelligence for Space Applications, part 1
(NASA-CP-2492-PT-1) p 89 N88-16360
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems
p 89 N88-16373
Artificial intelligence and space power systems automation
p 89 N88-16391
ELRIE-D: An expert system for failure diagnosis and recovery in the TCS of the European Ixhivelbin center (LURECA)
p 106 N88-16391
Planning activities in space
p 3 N88-16411
The innovative envelope as a basis for space station management system scheduling
p 102 N88-16427
Prototype resupply scheduler
p 9 N88-16428
Prototype space station automation system delivered and demonstrated at NASA
p 90 N88-16442
Applications of expert systems for satellite autonomy
p 90 N88-16443
Development of a coupled expert system for the spacecraft attitude control problem
p 91 N88-17215
Design knowledge capture for the space station
p 3 N88-17234
Expert system application in spacecraft subsystem controllers
p 90 N88-17238
TOAS: The Thermal Expert System (TEXPS) data acquisition system
p 102 N88-17246
Robotic intelligence issues for space manipulator monitoring control programming
p 92 N88-18508
On a knowledge based assisted system for highly autonomous control of experiment manipulators in the Man Tended Free Flyer
p 92 N88-18509
A knowledge-based approach for sensory controlled assembly operations
p 126 N88-19506
Treatment of unforeseen situations by crew: knowledge based diagnostic systems -- spacecraft maintenance
p 93 N88-19511

EXPLOITATION
Proceedings of the Fourth Annual US Space Development Conference
p 163 A88-22006

EXPOSURE
High intensity 5 eV O atom exposure facility for material degradation studies
p 96 N88-10047

EXTENSIONS
Personnel occupied assembly multiple robot power extensions (NASA-CR-182364)
p 66 N88-15184

EXTINGUISHING
Spacecraft fire detection and extinguishment: A bibliography
(NASA-CR-180880) p 158 N88-18612

EXTRAPOLATION
Numerical and numerical-analytical interfaces in structural thermal-dynamic interaction problems
(IAF PAPER 87-122) p 69 A88-16020

EXTRATERRESTRIAL LIFE
European activities in exobiological research in space
p 158 N88-19970

EXTRATERRESTRIAL RESOURCES
Space farming in the 21st century
p 106 A88-29237

EXTRAVEHICULAR ACTIVITY
European EVA requirements and space suit design
(IAF PAPER 87-61) p 152 A88-15503
Man in space -- Salyut 7 cosmonaut EVA operations
(IAF PAPER 87-77) p 162 A88-15852
EVA for a European Scenario
(SAE PAPER 871432) p 123 A88-21096
High pressure water electrolysis for the Space Station
(SAE PAPER 871473) p 61 A88-21109
An innovative exercise method to simulate orbital EVA work: Applications to PLSS automatic controls
(SAE PAPER 871475) p 154 A88-21130
On-orbit servicing enhancements with Clewlock EVA operations from the Spacehab module
(SAE PAPER 871496) p 124 A88-21148
Development of an automated checkout, servicing, and maintenance system for an EVAS Space Station
(SAE PAPER 871497) p 124 A88-21149
New tools for EVA operations
(SAE PAPER 871550) p 124 A88-21150
Evolution concept of an EVA space suit
(SAE PAPER 871516) p 124 A88-21163
Prospects on future EVA communications
(AIAA PAPER 88-0767) p 76 A88-27542
EVA construction and repair of tubular systems on Space Station
(AIAA PAPER 88-2958) p 125 A88-31381
Astronaut EVA construction of Space Station
(AIAA PAPER 88-2962) p 125 A88-31382
Structural Assembly Demonstration Experiment (SADE)
(NASA-CR-179395) p 25 N88-15899
Space Construction
(NASA-CP-2490) p 28 N88-19875
Experimental assembly of structures in EVA: Hardware morphology and development results
p 25 N88-19972
Access flight hardware design and development
p 26 N88-19973
Mission Peculiar Equipment Support Structure: A platform for space construction
p 25 N88-19974
Marshall Space Flight Center's role in EASE/ACCESS mission management
p 27 N88-19975
A monograph of the National Space Transportation System Office (NSTSO) integration activities conducted at the NASA Lyndon B. Johnson Space Center for the EASE/ACCESS payload flown on STS-61-B
p 27 N88-19976
Research and development at the Marshall Space Flight Center Neutral Buoyancy Simulator
p 5 N88-19978
A synopsis of the EVA training conducted on EASE/ACCESS for STS-61-B
p 125 N88-19979
Results of the ACCESS experiment
p 27 N88-19980
EASE (Experiment Assembly of Structures in EVA) overview of selected results
p 126 N88-19981
Space sun orthoesticular hazards protection development
(NASA-TM-101404) p 157 N88-12927
Automatic visions switching design for Extra vehicular Activity (EVA) communication system
p 77 N88-14983
Dual drum kinematic simulation of flexible arm robot for space station missions
p 69 N88-16398
NASA Office of Space Flight (OSF) in-orbit servicing program
p 129 N88-19498
In-orbit and laboratory exchange of ORUs designed/not designed for servicing
p 151 N88-19499
Utilization of MMS and EVA for the servicing of European Space Station
p 167 N88-19500
EVA: the technological challenge
p 129 N88-19535

EXTRAVEHICULAR MOBILITY UNITS
Electrochemically regenerable carbon dioxide-moisture control technology for an Advanced Extravehicular Mobility Unit
(SAE PAPER 871470) p 61 A88-21126
Development of a regenerable humidity and CO2 control system for an advanced EMU
(SAE PAPER 871471) p 61 A88-21127

EXTREME ULTRAVIOLET EXPLORER SATELLITE
Explorer Platform -- reusable spacecraft
(AIAA PAPER 88-0360) p 112 A88-20046

EXTREMELY LOW RADIO FREQUENCIES
The structure of ULF waves produced by a tethered satellite system
p 114 A88-23624

F

FABRICATION
Fabrication and assembly of an advanced composite Space Station fullerenes cell
p 11 A88-13199

FAILURE ANALYSIS
A systems engineering approach to automated failure cause diagnosis in space power systems
p 68 A88-11870
Applicability of A.I. techniques to the Space Station, a study case: Development of an expert system for on-board fault management
(IAF PAPER 87-30) p 93 A88-15822
Cooperative human-machine fault diagnosis
p 85 A88-21659
Space station software reliability analysis based on failures observed during testing at the multisystem integration facility
p 101 N88-14984
Treatment of unforeseen situations by crew: knowledge-based diagnostic systems -- spacecraft maintenance
p 93 N88-19511

FAILURE MODES
FMEAssist: A knowledge-based approach to Failure Modes and Effects Analysis
p 101 N88-16395

FAULT TOLERANCE
Space Station electric power system requirements and design
p 63 A88-11782

183

Fault tolerant onboard implementation of control procedures in tethered satellite p 110 A89-16295
Central processing unit for fault tolerant computing in Columbus p 139 A89-21254
Processes in construction of failure management expert systems from device design information p 86 A89-24230
Study of fault tolerant techniques for satellite data handling
(PTT/REP/0801/SAAB) p 101 N89-13660
National Aeronautics and Space Administration (NASA)-American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 2
(NASA-CR-172009-VOL-2) p 156 N89-14974
EURECA: An expert system for failure diagnosis and recovery in the TCS of the European retrievable carrier EURECA p 146 N89-16395

FEASIBILITY ANALYSIS

Feasibility study of a stabilizer fin for the tethered satellite system p 111 A89-16860
European retrievable carrier Eureca servicing by Hermes p 139 A89-21256
Preliminary study of a containerless processing facility for Columbus, executive summary
(ESA-ITT-AO/1-1.834/89F) p 96 N89-10203
Feasibility study for gas-gap simulation facility
(NASA-CR-177466) p 29 N89-13954
Feasibility study of a carbon dioxide observational platform system. Volume 2: Programmatics
(NASA-CR-180404) p 119 N89-14114
The feasibility of using TAE as the UI, for the space station and for other internal NASA tasks and projects p 9 N89-15619
Columbus feasibility studies. Volume 1: Requirements and system concept
(ETN-89-91073) p 140 N89-16790
Study of large solar arrays (SCLA), phase 2A
(BAE-SS/1109) p 79 N89-17108
Study of Large Solar Arrays (SCLA): Phase 2A. Amplifying information to final report (SS/1109)
(BAE-SS/1110) p 79 N89-17880
Rendezvous and docking verification and demonstration in orbit, executive summary
(MBB-303-16/90) p 91 N89-17719

FEDERAL BUDGETS

National Aeronautics and Space Administration Authorization Act, 1988
(PUB-LAW-100-147) p 165 N89-12422
Department of Housing and Urban Development-Independent Agencies Appropriations for fiscal year 1988. Thursday, 9 April 1987. National Aeronautics and Space Administration p 166 N89-12424
Department of Housing and Urban Development-Independent Agencies Appropriations for fiscal year 1988. Friday, 10 April 1987. National Aeronautics and Space Administration p 166 N89-12425
The 1988 NASA (National Aeronautics and Space Administration) authorization
(GPO-80-245) p 166 N89-14044
The 1988 National Aeronautics and Space Administration (NASA) authorization
(GPO-76-600) p 166 N89-14954

FEED SYSTEMS

Solar thermodynamic power systems in space p 72 A89-26150

FEEDBACK

New feedback design methodologies for large space structures: A multi-criterion optimization approach p 59 N89-12535

FEEDBACK CONTROL

Application of advanced automation techniques in the Space Station electrical power system p 75 A89-11955
Disturbance and vibration isolation in space stations by means of mechanical decoupling p 11 A89-13932
Feedback control for attitude control system of the elastic vehicle p 48 A89-14596
On the hierarchical control of the Space Station common module thermal system p 53 A89-14980
Control of gripper position of a compliant link using strain gauge measurements p 66 A89-14995
Deployment dynamics of accordian type of deployable solar arrays considering flexibility of closed control loops
(IAF PAPER 87-256) p 11 A89-15974
Large space structures testing
(AAS PAPER 87-036) p 13 A89-16998
Feedback control design for smooth, near minimum time rotational maneuvers of flexible spacecraft
(AIAA PAPER 88-0671) p 91 A89-22501
Flexible spacecraft maneuver - Inverse attitude control and modal stabilization p 53 A89-24291
Root locus method for active control of flexible systems p 50 A89-24596
Sensor and actuator selection for optimal closed-loop performance in the presence of correlated noise p 54 A89-27297
On local state feedback and stability domain estimation of nonlinear large scale systems p 144 A89-29245
A recursive pole placement method for large flexible structures p 19 A89-31047
Structural tailoring and feedback control synthesis: An interdisciplinary approach
(AIAA PAPER 89-2206) p 21 A89-32171
Optimal on-line measurement system configuration strategies
(AIAA PAPER 88-2341) p 9 A89-32284
Design of low order controllers for robust disturbance rejection in large space structures
(AD-A185202) p 59 N89-11078
Simultaneous structural and control optimization via linear quadratic regulator eigenstructure assignment p 28 N89-13622
Active control of flexural vibrations in beams p 59 N89-14882
Large-angle slewing maneuvers for flexible spacecraft
(NASA-CR-4127) p 60 N89-16360
Robust controller design for flexible structures
(AD-A187217) p 30 N89-18009

FERMENTATION

Design concepts for bioreactors in space p 45 N89-17179

FERROELECTRICITY

Physics and chemistry p 119 N89-11359

FIBER COMPOSITES

Stress rupture behavior of carbon-fiber metal-lined pressure vessels for 30-year operation in space
(AIAA PAPER 88-2479) p 10 A89-31591
Recent advances in dynamics of composite structures p 19 A89-31427
Carbon fiber reinforced glass matrix composites for space based applications
(AD-A184355) p 96 N89-12546
Oxidation and protection of fiberglass epoxy composite masts for photovoltaic arrays in the low Earth orbital environment
(NASA-TM-100839) p 97 N89-16736

FIBER OPTICS

Lighting considerations in a controlled environmental life support system
(SAE PAPER 871435) p 39 A89-21098
Optical fiber waveguides for spacecraft applications p 97 A89-21618

FIBER REINFORCED COMPOSITES

Carbon fiber reinforced glass matrix composites for space based applications
(AD-A184355) p 96 N89-12546

FINANCE

National Aeronautics and Space Administration Authorization Act, 1988
(PUB-LAW-100-147) p 165 N89-12422

FINITE ELEMENT METHOD

Finite-element model for the thermoelastic analysis of large composite space structures p 14 A89-19632
Convergence properties of modal cosh for certain distributed parameter systems p 20 A89-31170
A finite element method for time varying geometry in multibody structures
(AIAA PAPER 88-2234) p 21 A89-32197
Some thoughts on the convergence of the classical Rayleigh-Ritz method and the finite element method
(AIAA PAPER 89-2269) p 21 A89-32225
System identification of flexible structures
(AIAA PAPER 88-2361) p 23 A89-32301
The component mode method in a parallel computer environment
(AIAA PAPER 88-2439) p 8 A89-32355
A DMAP for updating dynamic mathematical models with measured data
(NLR-MP-86027-U) p 26 N89-10387

FINS

Feasibility study of a stabilizer fin for the tethered satellite system p 111 A89-16860
Preliminary investigation of stability of a fin-stiffened slender scout
(NASA-TM-4094) p 31 N89-19548

FIRE EXTINGUISHERS

Spacecraft Fire Safety
(NASA-CP-2476) p 156 N89-12520
Fire extinguishment and inhibition in spacecraft environments p 156 N89-12523
Space station internal environmental and safety concerns p 156 N89-12527

FIRE PREVENTION

Experiments to ensure Space Station fire safety - A challenge
(AIAA PAPER 88-0540) p 155 A89-22405
Spacecraft fire detection and extinguishment: A bibliography
(NASA-CR-183880) p 156 N89-19512

FIRES

A smoke removal unit
(SAE PAPER 871449) p 153 A89-21159
Spacecraft Fire Safety
(NASA-CP-2476) p 156 N89-12520
Techniques for fire detection p 156 N89-12521
Fire-related standards and testing p 156 N89-12522
Fire extinguishment and inhibition in spacecraft environments p 156 N89-12523
Fire-related medical science p 156 N89-12525
Space station internal environmental and safety concerns p 156 N89-12527
Microgravity combustion fundamentals p 79 N89-12528
Spacecraft material flammability testing and configurations p 96 N89-12529

FLAME PROPAGATION

Fire-related standards and testing p 156 N89-12522
Space station internal environmental and safety concerns p 156 N89-12527
Microgravity combustion fundamentals p 79 N89-12528

FLAMMABILITY

Spacecraft Fire Safety
(NASA-CP-2476) p 156 N89-12520
Fire-related standards and testing p 156 N89-12522
Spacecraft material flammability testing and configurations p 96 N89-12529

FLEXIBILITY

Solid modeling for the manipulative robot arm (power) and adaptive vision control for space station missions p 69 N89-16409

FLEXIBLE BODIES

Application of perturbation techniques to flexible multibody system dynamics p 14 A89-20908
A relatively general formulation for studying dynamics of the Space Station based MRMS with applications - Mobile Remote Manipulator System
(AIAA PAPER 88-0674) p 12 A89-22504
Synthesis of the flexible structures of complex systems p 15 A89-27148
Active vibration control on the DSLI flexible beam p 15 A89-27357
Control of distributed parameter systems with spillover using an augmented observer p 16 A89-27377
Active modification of wave reflection and transmission in flexible structures p 16 A89-27395
Identification and control of flexible structures p 54 A89-27768
Dynamics of large constrained flexible structures p 18 A89-28509
Integrated control of large flexible structures p 18 A89-29474
An application of IESIC/NASTRAN in the interdisciplinary analysis of large space-based structures p 17 A89-29819
Dynamics and control of a planar truss actuator p 55 A89-31564
A recursive pole placement method for large flexible structures p 19 A89-31567
Low authority threshold control for large flexible structures
(AIAA PAPER 89-2270) p 22 A89-32229
The nonlinear behavior of a passive zero-spring rate suspension system
(AIAA PAPER 89-2316) p 57 A89-32264
Dynamics and control of spacecraft with retargeting flexible antennas
(AIAA PAPER 89-2414) p 57 A89-32341
Model order reduction techniques in large space structure applications
(AIAA PAPER 89-2467) p 24 A89-32359
Recent advances in structural dynamics of large space structures
(NASA-TM-100513) p 26 N89-10867
Studies of the structural dynamic behavior of satellite antenna system
(AD-A185526) p 29 N89-14121
Robust controller design for flexible structures
(AD-A187217) p 30 N89-18009

FLEXIBLE SPACECRAFT

Theoretical principles of the optimal control of flexible spacecraft -- Russian book p 47 A89-10350
Robustness of active modal damping of large flexible structures p 11 A89-13929
Disturbance and vibration isolation in space stations by means of mechanical decoupling p 11 A89-13932
Feedback control for attitude control system of the elastic vehicle p 48 A89-14596
Large flexible solar arrays p 11 A89-15277

A unified matrix approach applied to dynamic formulation of complex space structures with nonlinear hinge forces and torques
(IAF PAPER 87-348) p 13 A88-16038
Dynamics and control during slewing maneuvers
(IAF PAPER 87-353) p 49 A88-16043
Reduced order models of a large flexible spacecraft
(IAF PAPER 87-356) p 13 A88-16046
Automatic control in space 1985 p 50 A86-15275
Modal damping measurement of MOS-1 Solar Array Paddle p 13 A88-16292
Mathematical models of flexible spacecraft dynamics - A survey of order reduction approaches
p 13 A88-16293
Application of adaptive observers to the control of flexible spacecraft p 50 A88-16296
Modelling and simulation of distributed flexibility in a spaceborne manipulator p 83 A88-16309
Development of the Mast Flight System linear dc motor inertial actuator
(AAS PAPER 87-021) p 13 A88-16380
Feedback control design for smooth, near minimum-time rotational maneuvers of flexible spacecraft
(AIAA PSPER 88-0671) p 51 A88-22501
Techniques for assessment of flexible space structure control performance
(AIAA PAPER 88-0677) p 52 A88-22507
Distributed systems approach to the identification of flexible structures p 11 A88-22608
Dynamics of earth-orbiting flexible satellites with multibody components p 52 A88-22609
Maneuvering and vibration control of flexible spacecraft p 52 A88-22932
Decentralized hierarchical control for large flexible spacecraft
(MSE-LR-967-87) p 52 A88-23982
Flexible spacecraft maneuver - inverse attitude control and modal stabilization p 53 A88-26291
Root locus method for active control of flexible systems p 53 A88-26536
An experimental study on flexible spacecraft three-axis attitude control p 53 A88-26356
A parameter robust LQG design synthesis with applications to control of flexible structures
p 15 A88-27319
Decentralized control of third generation spacecraft
p 15 A88-27356
Three-axis rotational maneuver and vibration stabilization of elastic spacecraft p 54 A88-27364
Sensor and actuator selection for optimal closed-loop performance in the presence of correlated noise
p 54 A88-27397
A homotopy algorithm for solving the optimal projection equations for fixed-order dynamic compensation - Existence, convergence and global optimality
p 16 A88-27601
Design and verification of the FLECS test structure - Flexible ECS-type structure p 54 A88-27779
Rotation stability of a deformable flight vehicle
p 144 A88-30115
Space Station - A focus for the development of structural dynamics scale model technology for large flexible space structures
(AIAA PAPER 88-2483) p 10 A88-31302
A finite element method for time varying geometry in multibody structures
(AIAA PAPER 88-2234) p 21 A88-32107
Control for energy dissipation in structures
(AIAA PAPER 88-2272) p 22 A88-32226
Multiple boundary condition test (MBCT) - Identification with mode shapes
(AIAA PAPER 88-2353) p 23 A88-32293
System identification of flexible structures
(AIAA PAPER 88-2361) p 23 A88-32301
Transient response of joint dominated space structures - A new linearization technique
(AIAA PAPER 88-2393) p 24 A88-32325
Structures and Materials Working Group report
p 25 N88-10093
Attitude Control Working Group report
p 57 N88-10099
Pinhole occulter experiment
(NASA-CR-179206) p 116 N88-11481
Control design challenges of large space systems and spacecraft control laboratory experiment (SCOLE)
(NASA-CR-178392) p 58 N88-11735
Natural control of flexible space structures
p 58 N88-12534
Simultaneous structural and control optimization via linear quadratic regulator eigenstructure assignment
p 26 N88-13602
Personnel occupied woven envelope robot power
(NASA-CR-182367) p 60 N88-15196
Large-angle slewing maneuvers for flexible spacecraft
(NASA-CR-4123) p 60 N88-16060
Emulating a flexible space structure Modeling
(NASA-TM-100320) p 30 N88-16812

FLEXING
Active control of flexural vibrations in beams
p 59 N88-14864

FLIGHT CONTROL
The impact of asymmetric physical properties on large space structures
(AIAA PAPER 88-2466) p 19 A88-31395

FLIGHT CREWS
The Soviet cosmonaut team, 1978-1987
p 144 A88-30165

FLIGHT HAZARDS
Department of Defense space policy and the development of a global policy for the control of space debris
(IAF PAPER 87-570) p 179 A88-16186
Artificial space debris -- Book p 130 A88-17944
The dangers of space debris - New developments and discoveries p 130 A88-18398
Debris hazard poses future threat p 131 A88-28695

FLIGHT MANAGEMENT SYSTEMS
Momentum management and attitude control design for a Space Station p 55 A88-26253

FLIGHT SAFETY
Space biologist's inflight safety considerations
(IAF PAPER 87-570) p 153 A88-16182
Theoretical considerations in designing operator displays for automated systems p 65 A88-21856
Safe rendezvous approach to a space station by impulsive transfers and continuous thrust arcs
p 151 N88-15486

FLIGHT SIMULATORS
Structural testing on the multi-axis simulator - An innovative simulation system for space vehicle structures
p 17 A88-29725

FLIGHT TESTS
The in-orbit technology demonstration programme of the European Space Agency
(IAF PAPER 87-03) p 135 A88-15803
The Aerosonde Flight Experiment
(IAF PAPER 87-197) p 2 A88-15938
Space Station habitat and laboratory module rack flight testing in the Spacelab Module
(SAE PAPER 871616) p 103 A88-21080
Technology demonstrator program for Space Station Environmental Control Life Support System
(SAE PAPER 871618) p 61 A88-21115

FLIGHT VEHICLES
Synthesis of the flexible structure of complex systems p 15 A88-27148
Rotation stability of a deformable flight vehicle
p 144 A88-30115

FLUID MANAGEMENT
Orbital Spacecraft Consumables Resupply System
p 120 A88-15292
Space station integrated propulsion and fluid system study. Fluid systems configuration database
(NASA-CR-179215) p 79 N88-11753
Space station resistojet system requirements and interface definition study
(NASA-CR-180832) p 80 N88-12541
All cryogenic and fluid management spacecraft technology program p 60 N88-15925
Orbital transfer vehicle studies overview
p 116 N88-15931
Large capacity cryopropellant orbital storage facility
p 60 N88-15932

FLUID MECHANICS
Prospects and problems in microgravity fluid science
p 2 A88-21569
A preliminary study of a fluid science laboratory for space station (Columbus). Part 4: Executive summary
(NLR-TR-87023-L-PT-4) p 79 N88-11072

FLUORIDES
Fluoride salts and container materials for thermal energy storage applications in the temperature range 973 - 1400 K p 92 A88-11804

FLUX DENSITY
Parametrics of nickel-hydrogen cell design -- for earth orbit vehicles p 75 A88-11912

FOILS
Chromic acid anodizing of aluminum foil
(NASA-CR-179417) p 97 N88-19077

FOLDING STRUCTURES
Multisurface control mechanism for a deployable antenna. Far Infrared and Submillimeter Space Telescope (FIRST) technology study
(NP-FA-0903) p 120 N88-16807
Automatic in-orbit payload deployment mechanisms, logistic operations and transport vehicle design considerations p 92 N88-19493

FOOD INTAKE
The determination of nutritional requirements for Safe Haven Food Supply System (emergency/survival foods)
p 45 N88-14856

FOOD PRODUCTION (IN SPACE)
Power requirements for an orbiting space farm
(IAF PAPER 87-242) p 70 A88-15489
The feasibility of Chlorella as the exchanger of CO2 for O2 and the food resources in the Space Station
p 43 A88-20136
Sunlight supply and gas exchange systems in microalgal bioreactor p 44 N88-12258

FORMALISM
A comparative survey of mathematical models for dynamic simulation of in-orbit manipulation operations
p 148 N88-19533

FORWARD SCATTERING
A measurement of the angular distribution of 5-eV atomic oxygen scattered off a solid surface in earth orbit
p 130 A88-16868

FRACTALS
Physics and chemistry p 119 N88-15359

FREE CONVECTION
Analysis of low gravity tolerance of model experiments for space station. Preliminary results for directional solidification
(NASA-CR-182657) p 10 N88-19648

FREE VIBRATION
Verification of large beam-type space structures
p 14 A88-19837

FREQUENCY ASSIGNMENT
High data rate modem simulation for the space station multiple access communications system
p 101 N88-14870

FREQUENCY MODULATION
An amplitude modulated laser system for distance and displacement measurement p 47 A88-12813

FREQUENCY RESPONSE
On the hierarchical control of the Space Station common module thermal system p 33 A88-14980

FRICTION
Absorptive tethers - A first test in space
p 111 A88-27781
Ignition and combustion of metals in oxygen
p 79 N88-12530

FUEL CELLS
Past, present and future activities in space power technology in the UK
(IAF PAPER 87-243) p 69 A88-15964

FUEL CONTROL
All cryogenic and fluid management spacecraft technology program p 60 N88-15925

FUEL TANKS
Slosh dynamics in a toroidal tank -- for orbit transfer vehicle cryogenic propellant storage p 78 A88-27888
Orbital Spacecraft Consumables Resupply System (OSCRS). Volume 1: Executive summary
(NASA-CR-172010) p 126 N88-13368

FUNCTIONAL DESIGN SPECIFICATIONS
Comparison of high temperature heat reaction concepts to system related requirements p 33 A88-11809
Evolutive concept of an EVA space suit
(SAE PAPER 871518) p 154 A88-21163
Access flight hardware design and development
p 26 N88-10873

FUNGAL DISEASES
A solid phase enzyme-linked immunosorbent assay for the antigenic detection of Legionella pneumophila (serogroup 1) A component for the space station diagnostic capability p 157 N88-14868

FURNACES
Vapor transport furnace for organic crystals and films
(AIAA PAPER 88-0160) p 113 A88-22113
Metallurgy laboratory for Columbus, executive summary
(SNAS-613-CA/TS) p 141 N88-10980

G

GAMMA RAY ASTRONOMY
A telescope for high energy gamma-ray measurements in the Space Station era
(AIAA PAPER 88-0652) p 114 A88-22485

GAMMA RAY OBSERVATORY
Orbital Spacecraft Consumables Resupply System (OSCRS). Volume 2: Study results
(NASA-CR-172011) p 126 N88-11687

GAMMA RAY TELESCOPES
A telescope for high energy gamma-ray measurements in the Space Station era
(AIAA PAPER 88-0652) p 114 A88-22485

GAS COOLED REACTORS
Particle bed reactor propulsion vehicle performance and characteristics as an orbital transfer rocket
p 78 A88-22707

GAS EXCHANGE
The feasibility of Chlorella as the exchanger of CO2 for O2 and the food resources in the Space Station
p 43 A88-20136

185

Sunlight supply and gas exchange systems in microbial bioreactor p 44 N89-12758

GAS RECOVERY
An overview of Japanese OEL/SS research activities p 44 N89-12767

GAS TRANSPORT
Vapor transport furnace for organic crystals and films [AIAA PAPER 88-0180] p 113 A88-22113

GAS-SOLID INTERACTIONS
Feasibility study for gas-grain simulation facility [NASA-CR-177468] p 20 N89-13054

GEARS
Assessment of the COPS/WAST project [NASA-CR-181365] p 21 N89-12360

GENETICS
A theoretical concept for static changes and shape changes in weightlessness p 157 N89-11381

GEOPHYSICS
Earth science missions for the Space Station p 111 A88-11239
Applications of tethered satellites to some problems of terrestrial physics [AIAA PAPER 88-0580] p 114 A88-22515

GEOSYNCHRONOUS ORBITS
Capture vector satellites p 139 A88-11726
Orbit design for a space ambulance vehicle p 149 A88-11213
GEO platform sensing - Technology solutions [IAF PAPER 87-08] p 122 A88-11409
Geostationary earth observations - Platform operations from the Space Station [IAF PAPER 87-18] p 139 A88-11814
Geostationary tether satellite system and its application to communications systems p 115 A88-28978
External surface charging mechanisms on spacecraft p 122 N89-11719
An allotment planning concept and related computer software for planning the feed satellite service at the 1988 space WARC [NASA-TM-100244] p 161 N89-11464

GET AWAY SPECIALS (GTS)
The 1987 Get Away Special Experimenter's Symposium [NASA-CP-2500] p 121 N89-11691
The NORSTAR Program: Space shuttle to space station p 167 N89-11770

GLASS
Carbon fiber reinforced glass matrix composites for space based applications [AD-A184334] p 94 N89-12546

GLASS FIBERS
Off to see the wizard -- space suits p 164 A88-22967
Mast material test program (MAMA TEP) [NASA-TM-100821] p 21 N89-14532

GOALS
Space Assembly, Maintenance, and Servicing Study (SAMSS) p 125 N89-10360
Space technology to meet future needs [NASA-CR-181473] p 165 N89-13610

GOVERNMENT/INDUSTRY RELATIONS
Advanced space solar dynamic power systems beyond IOC Space Station p 63 A88-11706
Structures and Materials Working Group report p 21 N89-13093

GRAPHITE-EPOXY COMPOSITES
Protective coatings for composite tubes in space applications p 88 A88-11239
Monitoring elastic stiffness degradation in graphite/epoxy composites p 14 A88-14173
Development and properties of aluminum-clad graphite/epoxy tubes for space structures [AIAA PAPER 88-2472] p 19 A88-31181
Experimental study of damping of graphite epoxy composite material at the Space Telescope truss system p 94 A88-31805

GRAVITATIONAL CONSTANT
Some considerations on measuring the Newtonian gravitational constant G in a rotating laboratory p 119 N89-10603

GRAVITATIONAL EFFECTS
Verification of large beam-type space structures p 14 A88-14637
Preliminary study of a gravitational biology facility for Columbus, executive summary [MATRA-ESPACE-TS/VT/89/2[illegible]] p 147 N89-10305
Allowable gravity levels for protein crystal growth and E. coli in a microgravity science [SP-R-86-525-2] p 147 N89-10364
A theoretical concept for static changes and shape changes in weightlessness p 157 N89-11381
JPRS report: Science and technology USSR: Space [JPRS-USP-87-006] p 160 N89-11653
Scientific objectives and functional requirements of life sciences in the Space Station p 159 N89-11964
The European Space Agency's role in life sciences and research in space p 149 N89-13894
Cardiovascular adaptation to zero-g during a long term flight (237 days) on board the Salyut 7 Soviet space station (1984) p 159 N89-13925
Artificial activity in space: results and hypotheses p 159 N89-13952

GRAVITATIONAL PHYSIOLOGY
Support of life science research in space by the DFVLR Biology Lab/ User Support Center (BMSC) [AIF PAPER 87-569] p 112 A88-16162
Providing artificial gravity - Physiologic limitations for rotating habitats [AIF PAPER 87-581] p 152 A88-16163
Scientific objectives and functional requirements of life sciences in the Space Station p 159 N89-16264
Cardiovascular adaptation to zero-g during a long term flight (237 days) on board the Salyut 7 Soviet space station (1984) p 159 N89-19925
Cardiac and peripheral circulation assessment by ultrasound on 3 astronauts during two 7-day space flights (1982, Salyut 7 - 1985, STS 51G) p 159 N89-19971
Mubilab: A project of a medical laboratory in space p 159 N89-19998

GRAVITY GRADIOMETERS
Recent developments in gravity gradiometry from the Space Shuttle-borne tethered satellite system p 112 A88-21131

GROUND BASED CONTROL
Teleoperation and control study -- orbital servicing [ESE TP-6266] p 67 N89-10059
Promising concepts for ground to orbit experiment teleoperation -- Columbus p 91 N89-10518
A teleoperated manipulator system concept for unmanned platforms -- Columbus p 91 N89-10537

GROUND EFFECT (COMMUNICATION)
Discharge prevention of geosynchronous orbit conductive thermal control materials and grounding systems p 76 N89-11732

GROUND HANDLING
EASE/ACCESS ground processing at Kennedy Space Center p 27 N89-13677

GROUND SUPPORT EQUIPMENT
Research on Electrodynamic Tether Effects and TEU experiment Electrical Ground Support Equipment (EGSE) -- tethered satellite [FB-87-2] p 110 N89-11378
AETE experiment Assembly, Integration, and Verification (AIV) activities [FB-87-6] p 117 N89-13180

GROUND SUPPORT SYSTEMS
Future European ground segment -- for Columbus Space Station [MBB-UR-(C)76-87] p 142 A88-21663
EASE/ACCESS ground processing at Kennedy Space Center p 27 N89-13677
Knowledge based simulation p 102 N89-16814
Columbus feasibility studies. Volume 4: Integration, test and operations [ETN-88-90076] p 167 N89-19514
Microgravity User Support Center (MUSC) for EURECA, Spacelab and Columbus missions p 165 N89-19947

GROUND TESTS
Research opportunities in microgravity science and applications during Shuttle flights p 108 A88-13104
Multiple boundary condition $\lambda^2 d(EA\,d^2)$ identification with mode shapes [AIAA PAPER 88-2353] p 23 A88-32793
Experimental component mode synthesis of structures with sloppy joints [AIAA PAPER 88-2411] p 24 A88-32339

GUIDANCE (MOTION)
Guidance and control 1987: Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Jan. 31-Feb. 4, 1987 p 51 A88-16976

GYROSTABILIZERS
Gyrostabilizer system of Kvant module p 61 N89-10099

H

HABITABILITY
Space station group activities habitability module study: A synopsis p 6 N89-10866

HABITATS
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 4: Supportability analysis of the 1.8m centrifuge p 6 N89-19481

HANDLING EQUIPMENT
Tether Elevator Crawler System (TECS) p 119 N89-11631

HARDWARE
Experimental assembly of structures in EVA: Hardware morphology and development issues p 26 N89-10872
Access flight hardware design and development p 26 N89-10873

HEALTH
An assessment of clinical chemical sensing technology for potential use in space station health maintenance facility [NASA-CR-172012] p 156 N89-12008

HEART
Ballistocardiography in weightlessness: mission-oriented research p 40 N89-10980

HEAT EXCHANGERS
Performance characteristics of moving belt radiators -- for spacecraft applications p 33 A88-12036

HEAT PIPES
Integrated heat pipe-thermal storage system performance evaluation p 32 A88-11803
Heat pipe radiators for solar dynamic space power system heat rejection p 33 A88-11807
An evaluation of heat pipe radiators incorporating pumped liquid return p 33 A88-11810
Modeling the performance of the monogroove with screen heat pipe for use in the radiator of the solar dynamic power system of the NASA Space Station [AIF PAPER 87-238] p 34 A88-15903
High thermal transport capacity heat pipes for space radiators [SAE PAPER 871509] p 35 A88-21155
Advanced radiator concepts utilizing honeycomb panel heat pipes [NASA-CR-172017] p 37 N89-12747

HEAT RADIATORS
Solar dynamic organic Rankine cycle heat rejection system simulation p 63 A88-11808
Comparison of high temperature heat rejection concepts to system related requirements p 33 A88-11809
Performance characteristics of moving belt radiators -- for spacecraft applications p 33 A88-12036
Thermal design of the equipment platforms [AIF PAPER 87-08] p 34 A88-15406
Space Station body mounted radiator design [SAE PAPER 871507] p 35 A88-21153
Estimating payload internal temperatures and radiator size for multimegawatt space platforms [SAE PAPER 881064] p 37 N89-11735
Advanced radiator concepts utilizing honeycomb panel heat pipes [NASA-CR-172017] p 37 N89-12747
Air revitalization and fluid management spacecraft technology program p 60 N89-15925

HEAT SHIELDING
Planar spectra of advanced layers on space shuttle and ACTS thermal protection system surface p 132 N89-14690

HEAT STORAGE
Selection of high temperature thermal energy storage materials for advanced solar dynamic space power systems p 69 A88-11801
Optimization and analysis of lithium hydride thermal energy storage device configurations for space power applications p 84 A88-11802
Integrated heat pipe-thermal storage system performance evaluation p 32 A88-11803
Fluoride salts and container materials for thermal energy storage applications in the temperature range 973 - 1400 K p 52 A88-11804
Impact of thermal energy storage on solar dynamic space power conversion system mass p 64 A88-11[illegible]
Structural assessment of a Space Station solar dynamic heat receiver thermal energy storage canister [AIAA PAPER 88-2467] p 72 A88-31396

HEAT TRANSFER
Thermal contact conductance of pressurized surfaces [AIAA PAPER 88-0467] p 36 A88-22343
Outgassing of spacecraft composites p 95 A88-31404
Thermal Control Working Group report p 39 N89-10094

HEAT TRANSMISSION
Pumped two-phase ammonia thermal bus test bed [SAE PAPER 871442] p 34 A88-21104
High thermal transport capacity heat pipes for space radiators [SAE PAPER 871509] p 71 A88-21155

HEAT TREATMENT
Outgassing data for selecting spacecraft materials [NASA-RP-1124] p 95 N89-10117

HEAVY LIFT LAUNCH VEHICLES
Soviet shuttle for Space Station role p 136 A88-10700

Department of Housing and Urban Development-Independent Agencies Appropriations for fiscal year 1988. Thursday, 9 April 1987 National Aeronautics and Space Administration
p 106 N88-12424
Department of Housing and Urban Development-Independent Agencies Appropriations for fiscal year 1988. Friday, 10 April 1987 National Aeronautics and Space Administration
p 106 N88-12425
Assessment of mixed fleet potential for space station launch and assembly
(NASA-TM-100050) p 107 N88-18628

HEMODYNAMICS
Cardiovascular adaptation to zero g during a long term flight (237 days) on board the Salyut 7 Soviet space station (1984) p 158 N88-10920
Cardiac and peripheral circulation assessment by ultrasound on 3 astronauts during two 7-day space flights (1982 Salyut 7 - 1985 STS 51G) p 158 N88-10921

HERMES MANNED SPACEPLANE
Evolution towards an autonomous European manned space infrastructure
(IAF PAPER 87-67) p 136 A88-15846
European rotravator carrier Eureca servicing by Hermes p 139 A88-21256
EVA, the technological challenge p 126 N88-19535

HEURISTIC METHODS
Planning activities in space p 9 N88-16017

HIGH ENERGY INTERACTIONS
Analysis of geophysical data bases and models for spacecraft interactions
(AD-A184600) p 100 N88-13375

HIGH FREQUENCIES
Control considerations for high frequency resonant power processing equipment used in large systems
p 67 A88-11429

HIGH PRESSURE
High pressure water electrolysis for the Space Station
(SAE PAPER 871673) p 41 A88-21128

HIGH RESOLUTION
SAFIRE - A novel high resolution cooled spectrometer for atmospheric research
(IAF PAPER 87-137) p 109 A88-15898

HIGH TEMPERATURE
Selection of high temperature thermal energy storage materials for advanced solar dynamic space power systems p 64 A88-11601

HIGH TEMPERATURE TESTS
Thermal response of integral multicomponent composites to a high-energy aerothermodynamic heating environment with surface temperatures to 1800 K
p 10 A88-12501

HIGH VOLTAGES
Coaxial tube array space transmission line characterization p 75 A88-11667

HILBERT SPACE
Distributed systems approach to the identification of flexible structures p 13 A88-23638

HISTORIES
Thirty years of the space age p 162 A88-16074
Spacecraft fire detection and extinguishment: A bibliography
(NASA-CR-180880) p 158 N88-19012

HOLOGRAPHIC INTERFEROMETRY
ISIS: Imaging Speckle Interferometer in Space
p 116 N88-10525

HOMOTOPY THEORY
A homotopy algorithm for solving the optimal projection equations for fixed-order dynamic compensation - Existence, convergence and global optimality
p 16 A88-21401

HONEYCOMB STRUCTURES
The use of advanced materials in space structure applications
(IAF PAPER 87-305) p 94 A88-16936
Hybrid honeycomb panel heat rejection system
(SAE PAPER 871419) p 34 A88-21080
Solar conserging method p 27 N88-17034
Advanced radiator concepts utilizing honeycomb panel heat pipes
(NASA-CR-172017) p 37 N88-12767

HOOP COLUMN ANTENNAS
Studies of the structural dynamic behavior of satellite antenna system
(AD-A185587) p 39 N88-14121

HOUSEKEEPING (SPACECRAFT)
A dishwasher for the Space Station
(SAE PAPER 871411) p 38 A88-21076

HUBBLE SPACE TELESCOPE
Large flexible solar arrays p 11 A88-15077
Hubble Space Telescope servicing - Experience base for a new era
(IAF PAPER 87-56) p 139 A88-15839
Experimental study of damping of graphite epoxy composite material of the Space Telescope truss system
p 56 A88-21605
Department of Housing and Urban Development-Independent Agencies Appropriations for fiscal year 1988. Friday, 10 April 1987 National Aeronautics and Space Administration
p 106 N88-12425
Artificial intelligence and space power systems automation p 65 N88-16381

HUMAN BEHAVIOR
Cosmonaut behavior in orbital flight situation - Preliminary ethological analysis
(IAF PAPER 87-526) p 112 A88-16151

HUMAN FACTORS ENGINEERING
Crew factors in the design of the Space Station
p 151 A88-10947
Human factor design of habitable space facilities
(IAF PAPER 87-540) p 39 A88-16166
Low-cost prototypes for human factors evaluation of Space Station crew equipment
(IAF PAPER 87-553) p 152 A88-16170
Spacecraft fire detection and extinguishment: A bibliography
(NASA-CR-180880) p 158 N88-19012
Space station architectural elements model study: Space station human factors research review
p 102 N88-19864
Space station group activities habitability module study: A synopsis p 0 N88-19896
Full scale architectural simulation techniques for space stations p 10 N88-19897
Social factors in space station interiors
p 60 N88-19898

HUMAN PERFORMANCE
A human performance modeling approach to intelligent decision support systems p 90 N88-11042

HUMAN REACTIONS
Cardiovascular adaptation to zero g during a long term flight (237 days) on board the Salyut 7 Soviet space station (1984) p 158 N88-10920

HUMAN WASTES
OSSA Space Station waste inventory
(SAE PAPER 871413) p 39 A88-21079

HUMIDITY
Development of a regenerable humidity and CO2 control system for an advanced EMU
(SAE PAPER 871471) p 41 A88-21127

HYDRAZINES
In vitro test of a 22 Newton (5 lbf) hydrazine rocket
(NASA-TM-100722) p 79 N88-11750

HYDROGEN OXYGEN ENGINES
Solar thermal OTVs in comparison with electrical and chemical propulsion systems
(IAF PAPER 87-199) p 77 A88-15998
Space Station propulsion system technology
p 79 A88-21233
Space station propulsion
(NASA-TM-100216) p 79 N88-11196
Space station propulsion technology
(NASA-CR-179360) p 80 N88-19605

HYDROGEN OXYGEN FUEL CELLS
Aspects and possibilities of an integrated energy and media supply system on H2/O2 basis for manned space stations in the low earth orbit
(IAF PAPER 87-261) p 59 A88-15963

HYDROGEN PRODUCTION
Static feed electrolyzer technology advancement for space application
(SAE PAPER 871452) p 40 A88-21110

HYPERBARIC CHAMBERS
Space station internal environmental and safety concerns p 156 N88-12527

HYPERSONIC VEHICLES
Aerothermodynamics - A key to new aerospace transport systems
(DGLR PAPER 87-077) p 4 A88-22407

HYPERVELOCITY IMPACT
Space Station probability of no penetration due to meteoroid and orbital debris impact
(AIAA PAPER 88-2464) p 14 A88-21387
Hypervelocity impact damage assessment for Space Station
(AIAA PAPER 88-2465) p 14 A88-21388
Analysis of oblique hypervelocity impact phenomena
(AIAA PAPER 88-2570) p 23 A88-22307

I

ICE
Planetary science p 5 N88-15356
Atmospheric science p 5 N88-15357

IGNITION
Ignition and combustion of metals in oxygen
p 79 N88-12530

IMAGE ANALYSIS
Focus of attention in systems for visual monitoring of experiments p 112 A88-21659

IMMUNOASSAY
A solid phase enzyme-linked immunosorbent assay for the antigenic detection of Legionella pneumophila (serogroup 1): A component for the space station diagnostic capability p 157 N88-14888

IMPACT DAMAGE
Hypervelocity impact damage assessment for Space Station
(AIAA PAPER 88-2465) p 15 A88-21388
Space Station pressure wall repair techniques
(AIAA PAPER 88-2466) p 19 A88-21397
Analysis of oblique hypervelocity impact phenomena
(AIAA PAPER 88-2570) p 23 A88-22307
Space station integrated wall damage and penetration damage control. Task 5: Space debris measurement, mapping and characterization system
(NASA-CR-179381) p 35 N88-17088

IMPACT LOADS
Investigation of damping from nonlinear viscous joints of large space structures p 56 A88-21536

IMPACT TESTS
Analysis of oblique hypervelocity impact phenomena
(AIAA PAPER 88-2570) p 23 A88-22307

INCOMPRESSIBLE FLUIDS
Viscous damped space structure for reduced g/tar p 26 N88-19423

INDIAN SPACECRAFT
Deployment dynamics of accordion type of deployable solar arrays considering flexibility of closed control loops
(IAF PAPER 87-256) p 11 A88-15974

INELASTIC COLLISIONS
Physics and chemistry p 119 N88-15359

INERT ATMOSPHERE
Spacecraft Fire Safety
(NASA-CP-2478) p 158 N88-12520
Fire extinguishment and inhibition in spacecraft environments p 158 N88-12523

INERTIAL GUIDANCE
Gyrostabilizer system of Kvant module
p 60 N88-16109

INFLATABLE STRUCTURES
Large inflatable, space-rigidized antenna reflectors - Land mobile services development
(IAF PAPER 87-315) p 12 A88-16013

INFORMATION DISSEMINATION
Spacecraft 2000 program overview
p 160 N88-10580

INFORMATION MANAGEMENT
ENVIRONET database on vibroacoustics
(AIAA PAPER 88-0108) p 90 A88-20011
Network management for the Space Station Information System
(AIAA PAPER 88-0118) p 99 A88-20092
Foundation: Transforming data bases into knowledge bases p 102 N88-16429

INFORMATION SYSTEMS
Space Station Information System - Concepts and international issues
(IAF PAPER 87-76) p 98 A88-15861
Network management for the Space Station Information System
(AIAA PAPER 88-0118) p 99 A88-20092
OSSA's Telescience concept for the Space Station era
(AIAA PAPER 88-0120) p 112 A88-20093
Space station software reliability analysis based on failures observed during testing at the multisystem integration facility p 101 N88-14894
Critical issues in NASA information systems
(NASA-CR-182300) p 10 N88-16577

INFRARED ASTRONOMY
Workshop on Technology Development Issues for the Large Deployable Reflector (LDR)
(NASA-CP-2467) p 32 N88-20235

INFRARED TELESCOPES
Multisurface control mechanism for a deployable antenna. Far Infrared and Submillimeter Space Telescope (FIRST) technology study
(RP-FA-0003) p 121 N88-10807
Workshop on Technology Development Issues for the Large Deployable Reflector (LDR)
(NASA-CP-2467) p 32 N88-20235

INSPECTION
Method of radiographic inspection of wooden members
(NASA-CASE-LAR-13724-1) p 149 N88-23943

INSTRUMENT ERRORS
A model-free method for mass spectrometer response correction -- for oxygen consumption and cardiac output calculation p 111 A88-16883

INSTRUMENT PACKAGES
OSSA Space Station waste inventory
(SAE PAPER 871413) p 39 A88-21079

187

INSURANCE (CONTRACTS)
Review of commercial spacecraft: Recovery and repair experiences. Implications for future spacecraft designs and operations p 128 N88-19526
INTERACTIVE CONTROL
A packetised remote visual access data system for Space Station interactive payload operations p 99 A88-21253
INTERCOSMOS SATELLITES
Intercosmos: An example of cooperation — Russian book p 142 A88-24793
INTERFACES
The feasibility of using TAE as the UIL for the space station and for other internal NASA tasks and projects p 9 N88-15618
INTERFEROMETRY
Space station based interferometry p 116 N88-10628
INTERNAL PRESSURE
Off to see the wizard — space suits p 164 A88-22957
INTERNATIONAL COOPERATION
Negotiating the Space Station p 160 A88-13445
The applicable legal regime for international cooperation on space stations p 133 A88-13446
The applicable legal regime for international cooperation p 160 A88-13448
Proprietary rights and commercial use of space stations p 161 A88-13453
International Space Station operations. New dimensions - October 13, 1987
[IAF PAPER 87-13] p 122 A88-15810
Columbus, present programme status
[IAF PAPER 87-62] p 135 A88-15841
NASA and the Space Station - Current Status
[IAF PAPER 87-64] p 161 A88-15843
United States Space Station technical and programmatic interfaces
[IAF PAPER 87-65] p 162 A88-15844
The Columbus space segment
[IAF PAPER 87-66] p 126 A88-15845
Space Station Information System - Concepts and international issues
[IAF PAPER 87-76] p 98 A88-15851
Science plans and requirements for the U.S./International Space Station
[IAF PAPER 87-93] p 103 A88-15864
One mission on board the MIR Space Station - The French-Soviet project Aragatz
[IAF PAPER 87-96] p 137 A88-15867
Space Station services and design features for users
[IAF PAPER 87-99] p 103 A88-15870
The Columbus Attached Pressurized Module - System and management aspects of international cooperation p 139 A88-21252
The Columbus system aspects p 140 A88-21556
Principles of operations cooperation between the United States and Europe p 141 A88-21564
International cooperation in the Space Station p 142 A88-21573
Partnership, a key issue in the International Space Station cooperation p 142 A88-21575
Intercosmos: An example of cooperation — Russian book p 142 A88-24793
Colloquium on the Law of Outer Space, 29th, Stockholm, Sweden, Oct. 7-12, 1985, Proceedings p 164 A88-26197
Space station: Leadership for the future
[NASA-PAM-509/8-87] p 165 N88-10072
Satellite power systems under consideration by the United Nations p 74 N88-16773
The NORSTAR Program: Space shuttle to space station p 167 N88-17710
INTERNATIONAL LAW
Status of ongoing government-level negotiations on space stations p 132 A88-13444
INTERNATIONAL RELATIONS
1986 - Very good year for Soviets p 136 A88-16379
The Spacebus platforms
[AIAA PAPER 88-0775] p 115 A88-27535
INTERPLANETARY DUST
Planetary science p 5 N88-15356
INTERPLANETARY FLIGHT
Manned Mars mission accomodation by the evolutionary Space Station
[IAF PAPER 87-438] p 105 A88-16097
INTERPLANETARY MEDIUM
Solar-terrestrial research in the space station era p 116 N88-10747
JPRS report: Science and technology: USSR: Space
[JPRS-USP-87-006] p 146 N88-16063
INTERPLANETARY NAVIGATION
Solar- and nuclear electric propulsion for high energy orbits
[IAF PAPER 87-198] p 77 A88-15935
INTERPLANETARY SPACE
Environmental interactions of solar generators in space p 72 N88-11730
INTERPOLATION
Numerical and numerical-analytical interfaces in structural thermal-dynamic interactive problems
[IAF PAPER 87-322] p 69 A88-16020
INTERSTELLAR MATTER
Exobiology and life science p 118 N88-15356
INTERVALS
Solar-terrestrial research in the space station era p 116 N88-10747
INVENTORY MANAGEMENT
Inventory behavior at remote sites p 5 N88-14873
IODINE
Consequences of bacterial resistance to disinfection by iodine in potable water
[SAE PAPER 871489] p 42 A88-21143
Medical effects of iodine disinfection products in spacecraft water
[SAE PAPER 871490] p 154 A88-21144
IODINE LASERS
Preliminary conceptual design and weight of a one-megawatt space-based laser power station utilizing a solar-pumped iodine laser p 65 A88-11816
ION BEAMS
Degradation mechanisms of materials for large space systems in low Earth orbit
[NASA-CR-181472] p 96 N88-10896
ION ENGINES
Solar thermal OTVs in comparison with electrical and chemical propulsion systems
[IAF PAPER 87-199] p 77 A88-15936
IONIZATION
Observations of ions generated on or near satellite surfaces
[AIAA PAPER 88-0434] p 130 A88-22323
IONIZING RADIATION
Determination of cosmic-ray characteristics on Salyut-7 p 131 A88-26349
IONOSPHERIC SOUNDING
Outer atmospheric research
[AIAA PAPER 88-0686] p 8 A88-22512
Downward-deployed tethered platforms for high enthalpy aerothermodynamic research
[AIAA PAPER 88-0688] p 114 A88-22514
Alfven waves from an electrodynamic tethered satellite system p 115 A88-25890
IRRADIATION
Degradation mechanisms of materials for large space systems in low Earth orbit
[NASA-CR-181472] p 96 N88-10896
Space environmental effects on polymeric materials
[NASA-CR-182454] p 97 N88-16879
ISOLATORS
Biosolation on the Space Station - Of mice and men
[SAE PAPER 871457] p 153 A88-21116
ITALIAN SPACE PROGRAM
A new Italian proposal for a Space Station Assembly and Servicing Vehicle (ASMV)
[IAF PAPER 87-37] p 135 A88-15827
Aerospatiale studies for IOC and AOC -- Initial Operational Capability and Autonomous Operating Capability p 141 A88-21562
ITERATIVE SOLUTION
Application of perturbation techniques to flexible multibody system dynamics p 14 A88-20908
The component-mode method in a parallel computer environment
[AIAA PAPER 88-2438] p 9 A88-32355

J

JACOBI MATRIX METHOD
The component-mode method in a parallel computer environment
[AIAA PAPER 88-2438] p 9 A88-32355
JAPAN
NASDA's new test facilities for satellites and rockets p 147 N88-16951
JAPANESE SPACE PROGRAM
A legal framework for Space Station activities p 160 A88-13447
JEM present project status — Japan Experiment Module
[IAF PAPER 87-63] p 135 A88-15842
Automation and robotics technology application to JEM — Japanese Experiment Module
[IAF PAPER 87-74] p 136 A88-15849
Japan - Future space samurai? p 138 A88-16223
Toward new materials processing in space p 2 A88-21572
Japan's contribution to the Space Station program p 142 A88-21574
Japan takes charge p 143 A88-27952
Space life sciences in Japan p 164 A88-29107
Long-term strategy of space science in Japan p 143 A88-29195
An overview of the current Earth observation programs (Europe, USA, and Japan) p 167 N88-16778
JAPANESE SPACECRAFT
Conceptual design of the advanced technology platform
[IAF PAPER 87-C2] p 108 A88-15802
Development scenario of H-II Orbiting Plane, HOPE
[IAF PAPER 87-210] p 48 A88-15943
Modal damping measurement of MOS-1 Solar Array Paddle p 13 A88-16292
Environmental control and life support system for Japanese Experiment Module
[SAE PAPER 871429] p 39 A88-21092
JET FLOW
Raman spectra of adsorbed layers on space shuttle and AOTV thermal protection system surfaces p 132 N88-14690
JOINTS (JUNCTIONS)
Modeling and simulation of distributed flexibility in a spaceborne manipulator p 83 A88-16309
Measurement and modeling of joint damping in space structures
[AIAA PAPER 88-2449] p 17 A88-31378
Dispersion, damping and confinement of propagating pulses in large space structures
[AIAA PAPER 88-2311] p 22 A88-32259
Transient response of joint dominated space structures - A new linearization technique
[AIAA PAPER 88-2393] p 24 A88-32325
Experimental component mode synthesis of structures with sloppy joints
[AIAA PAPER 88-2411] p 24 A88-32339
Effect of joint damping and joint nonlinearity on the dynamics of space structures
[AIAA PAPER 88-2460] p 57 A88-32362
Considerations concerning a thermal joint for a deployable or steerable battery radiator for the Columbus Polar Platform
[NLR-TR-86055-U] p 37 N88-11739
JUDGMENTS
Space vehicle approach velocity judgments under simulated visual space conditions
[NASA-TM-89437] p 156 N88-19094

K

KALMAN FILTERS
Optimal on-line measurement system configuration strategies
[AIAA PAPER 88-2341] p 8 A88-32284
KARMAN VORTEX STREET
ESA Bulletin No. 25
[ISSN-0376-4265] p 146 N88-16767
KINEMATICS
Dynamics, control and sensor issues pertinent to robotic hands for the EVA retriever system p 86 N88-14876
Goal driven kinematic simulation of flexible arm robot for space station missions p 89 N88-16388
KINETIC THEORY
Physics and chemistry p 118 N88-15359
KNOWLEDGE
Third Conference on Artificial Intelligence for Space Applications, part 1
[NASA-CP-2492-Pt-1] p 89 N88-16360
Knowledge-based simulation p 102 N88-16404
Foundation: Transforming data bases into knowledge bases p 102 N88-16423

L

LABORATORIES
Research opportunities in microgravity science and applications during Shuttle hiatus p 106 A88-13164
Dynamics of spacecraft control laboratory experiment (SCOLE) slew maneuvers
[NASA-CR-4098] p 57 N88-10082
Control design challenges of large space systems and spacecraft control laboratory experiment (SCOLE)
[NASA-CR-178392] p 58 N88-11735
LABORATORY EQUIPMENT
A preliminary study of a fluid science laboratory for space station (Columbus). Part 4: Executive summary
[NLR-TR-87023-L-PT-4] p 79 N88-11072
Exobiology and botany facilities for EURECA p 148 N88-19898
LAMINATES
Thermal response of integral multicomponent composites to a high-energy aerothermodynamic heating environment with surface temperature to 1800 K p 10 A88-12591

LAND MOBILE SATELLITE SERVICE
Communication satellite technology trends
p 76 N88-10088
Study of mobile communications payload for Columbus Polar Platforms
[ITS-TR-056A/86] p 76 N88-10220

LARGE SPACE STRUCTURES
Self-shadowing effects on the thermal-structural response of orbiting trusses p 32 A88-11734
Control considerations for high frequency, resonant, power processing equipment used in large systems
p 47 A88-11829
Fabrication and assembly of an advanced composite Space Station tetrahuss cell p 11 A88-13189
Robustness of active modal damping of large flexible structures p 11 A88-13929
Large flexible solar arrays p 11 A88-15277
Recent advances in structural dynamics of large space structures
[IAF PAPER 87-5*] p 11 A88-15836
A general truss system for very large space base foundations, with application to the solar power satellite
[IAF PAPER 87-248] p 11 A88-15967
The use of advanced materials in space structure applications
[IAF PAPER 87-305] p 94 A88-16006
Stress and deformation analysis and tests of composite structures for space application
[IAF PAPER 87-312] p 12 A88-16011
Large inflatable, space-rigidized antenna reflectors - Land mobile services development
[IAF PAPER 87-315] p 12 A88-16013
Structural design and decoupled control — of large space structures
[IAF PAPER 87-318] p 48 A88-16016
Two-dimensionally deployable 'SHOF' truss
[IAF PAPER 87-319] p 12 A88-16017
Capabilities and special features concerning structural optimization of spacecraft structures
[IAF PAPER 87-320] p 12 A88-16018
Sensitivity analysis and optimal design for large unrestrained structures
[IAF PAPER 87-321] p 12 A88-16019
Numerical and numerical-analytical interfaces in structural thermal-dynamic interactive problems
[IAF PAPER 87-322] p 49 A88-16020
The dynamics and control of large space structures after the onset of thermal shock
[IAF PAPER 87-351] p 49 A88-16041
Mission function control applied to slew maneuver
[IAF PAPER 87-354] p 49 A88-16044
Reduced order models of a large flexible spacecraft
[IAF PAPER 87-356] p 13 A88-16046
Large space structures testing
[AAS PAPER 87-036] p 13 A88-16096
Finite-element model for the thermoelastic analysis of large composite space structures p 14 A88-18632
Verification of large beam-type space structures
p 14 A88-18637
Formulation of rigid multibody systems in space
p 14 A88-21221
A simple model for the initial phase of a water plasma cloud about a large structure in space
[AIAA PAPER 88-0430] p 55 A88-22320
Shuttle experiments to measure the optical environments surrounding large space structures
[AIAA PAPER 88-0432] p 14 A88-22321
Large deployable reflector thermal characteristics in low earth orbits
[AIAA PAPER 88-0471] p 36 A88-22347
Techniques for assessment of flexible space structure control performance
[AIAA PAPER 88-0677] p 52 A88-22507
Distributed systems approach to the identification of flexible structures p 15 A88-22608
Dynamics of earth-orbiting flexible satellites with multibody components p 52 A88-22609
Maneuvering and vibration control of flexible spacecraft p 52 A88-22932
Decentralized/hierarchical control for large flexible spacecraft
[MBB-UR-967-87] p 52 A88-23982
Optimization of actively controlled structures using goal programming techniques p 53 A88-25797
Thermal environment simulator for vacuum testing of large spacecraft p 36 A88-25979
Robust stabilization under mode truncation and parameter variations p 15 A88-27325
Decentralized control of third generation spacecraft
p 15 A88-27356
Structural decomposition approach to design of robust decentralized controllers for large scale systems
p 53 A88-27358
A survey of decentralized control techniques for large space structures p 16 A88-27359
Control of distributed parameter systems with spillover using an augmented observer p 16 A88-27377
Optimum design of structures with multiple constraints
p 16 A88-28042
A criterion for shape control robustness of space structures p 16 A88-29720
An application of MSC/NASTRAN in the interdisciplinary analysis of large space-based structures
p 17 A88-29819
Large space structures - Structural concepts and materials
[SAE PAPER 872429] p 17 A88-30999
AIAA 'OM Issues of the International Space Station, Conference, Williamsburg, VA, Apr 21-22, 1988, Technical Papers p 17 A88-31376
Structures and materials technology for Space Station
[AIAA PAPER 88-2446] p 17 A88-31377
Measurement and modeling of joint damping in space structures
[AIAA PAPER 88-2449] p 17 A88-31378
Shuttle based assembly of Space Station
[AIAA PAPER 88-2452] p 125 A88-31379
EVA construction and repair of tubular systems on Space Station
[AIAA PAPER 88-2456] p 125 A88-31381
Nondestructive construction error detection in large space structures
[AIAA PAPER 88-2460] p 18 A88-31383
Damage detection and location in large space trusses
[AIAA PAPER 88-2461] p 18 A88-31384
Development and properties of aluminum-clad graphite/epoxy tubes for space structures
[AIAA PAPER 88-2472] p 19 A88-31389
Space Station - A focus for the development of structural dynamics scale model technology for large flexible space structures
[AIAA PAPER 88-2483] p 19 A88-31392
Spillover stabilization of large space structures
[AIAA PAPER 88-2484] p 55 A88-31393
The impact of asymmetric physical properties on large space structures
[AIAA PAPER 88-2486] p 19 A88-31395
A composite structural system for a large collapsible space antenna p 19 A88-31403
A recursive pole placement method for large flexible structures p 19 A88-31567
Convergence properties of modal costs for certain distributed parameter systems p 20 A88-31570
Design and analysis of passively damped large space structures p 56 A88-31574
[illegible]tal coupling of structures with complex storage [illegible] p 20 A88-31580
Large space structure damping treatment performance - Analytic and test results p 20 A88-31586
Fractional derivatives in the description of damping materials and phenomena p 20 A88-31589
Very high damping in large space structures
p 20 A88-31594
Investigation of damping from nonlinear sleeve joints of large space structures p 56 A88-31596
Comparison of experimental techniques in the measurement of damping capacity of metal-matrix composites p 56 A88-31600
Experimental studies of active members in control of large space structures
[AIAA PAPER 88-2207] p 56 A88-32179
Analytical and experimental investigations for satellite antenna deployment mechanisms
[AIAA PAPER 88-2225] p 76 A88-32189
Dynamic characterization of structures by pulse probing and deconvolution
[AIAA PAPER 88-2230] p 21 A88-32193
A finite element method for time varying geometry in multibody structures
[AIAA PAPER 88-2234] p 21 A88-32197
Low authority threshold control for large flexible structures
[AIAA PAPER 88-2270] p 22 A88-32226
Control for energy dissipation in structures
[AIAA PAPER 88-2272] p 22 A88-32228
Vibration control of truss beam structures using axial force actuators
[AIAA PAPER 88-2273] p 22 A88-32229
Solution of structural analysis problems on a parallel computer
[AIAA PAPER 88-2287] p 22 A88-32240
Dispersion, damping and confinement of propagating pulses in large space structures
[AIAA PAPER 88-2311] p 22 A88-32259
The nonlinear behavior of a passive zero-spring-rate suspension system
[AIAA PAPER 88-2316] p 57 A88-32264
Optimal reconfiguration of thermally distorted wire mesh reflectors for large space antennas
[AIAA PAPER 88-2340] p 22 A88-32283
Optimal on-line measurement system configuration strategies
[AIAA PAPER 88-2341] p 8 A88-32284
Multiple boundary condition test (MBCT) - Identification with mode shapes
[AIAA PAPER 88-2353] p 23 A88-32293
Structural model verification with LQG theory — Linear Quadratic Optimization
[AIAA PAPER 88-2360] p 23 A88-32300
System identification of flexible structures
[AIAA PAPER 88-2361] p 23 A88-32301
Transient response of joint dominated space structures - A new linearization technique
[AIAA PAPER 88-2393] p 24 A88-32325
Experimental component mode synthesis of structures with sloppy joints
[AIAA PAPER 88-2411] p 24 A88-32339
Torturing recursive parameter identification algorithms with a gap nonlinearity
[AIAA PAPER 88-2439] p 24 A88-32356
Model order reduction techniques in large space structure applications
[AIAA PAPER 88-2467] p 24 A88-32359
Passive damping for space truss structures
[AIAA PAPER 88-2469] p 24 A88-32360
Effect of joint damping and joint nonlinearity on the dynamics of space structures
[AIAA PAPER 88-2480] p 57 A88-32362
Enhancement of frequency and damping in large space structures with extendable members
[AIAA PAPER 88-2482] p 57 A88-32363
Survey of parameter estimation methods in experimental modal analysis p 24 A88-32716
Assessment of the COFS1/MAST I project
[NASA-CR-181366] p 25 N88-10040
A DMAP for updating dynamic mathematical models with measured data
[NLR-MP-86027-U] p 26 N88-10067
Recent advances in structural dynamics of large space structures
[NASA-TM-100513] p 26 N88-10967
Structural Assembly Demonstration Experiment (SADE)
[NASA-CR-179205] p 26 N88-10868
Experimental assembly of structures in EVA: Hardware morphology and development issues p 26 N88-10872
Marshall Space Flight Center's role in EASE/ACCESS mission management p 27 N88-10875
A monograph of the National Space Transportation System Office (NSTSO) integration activities conducted at the NASA Lyndon B. Johnson Space Center for the EASE/ACCESS payload flown on STS 61-B
p 27 N88-10876
Research and development at the Marshall Space Flight Center Neutral Buoyancy Simulator p 5 N88-10878
A synopsis of the EVA training conducted on EASE/ACCESS for STS-61-B p 126 N88-10879
Results of the ACCESS experiment
p 27 N88-10880
EASE (Experimental Assembly of Structures in EVA) overview of selected results p 126 N88-10881
Overview of crew member energy expenditure during Shuttle Flight 61-B EASE/ACCESS task performance
p 156 N88-10882
Pinhole occulter experiment
[NASA-CR-179206] p 116 N88-11481
Control design challenges of large space systems and spacecraft control laboratory experiment (SCOLE)
[NASA-CR-179392] p 58 N88-11735
Adaptive control of Large Space Structure (LSS)
[ISAS-R-621] p 58 N88-11740
Wavefront error sensing
[NASA-CR-181504] p 76 N88-12030
Stochastic model of the NASA/MSFC ground facility for large space structures with uncertain parameters: The maximum entropy approach
[NASA-CR-181489] p 27 N88-12043
New feedback design methodologies for large space structures: A multi-criterion optimization approach
p 59 N88-12535
Computational methods for problems in aerodynamics and large space structure using parallel and vector architectures
[AD-A185401] p 27 N88-13294
Survey on large scale system control methods
[NASA-CR-181556] p 59 N88-13374
Design of low order controllers for robust disturbance rejection in large space structures
[AD-A185200] p 59 N88-13376
Modeling and control of large flexible vehicles in the atmosphere and space
[AD-A185368] p 27 N88-13377
Potential for on-orbit manufacture of large space structures using the pultrusion process
[NASA-TM-40*6] p 28 N88-13388

Optimal control of large space structures via generalized inverse matrix
[NASA-CR-182236] p 59 N88-13907
Approaches and possible improvements in the area of multibody dynamics modeling
[NASA-CR-179227] p 28 N88-14067
Investigation of design concepts for large space structures to support military applications
[AD-A186098] p 29 N88-15000
Natural frequencies and structural integrity assessment of large space structures
[AD-A186139] p 29 N88-15001
Wave propagation experiments on 22-bay lattice
[AD-A186140] p 29 N88-15002
Maximum entropy/optimal projection design synthesis for decentralized control of large space structures
[AD-A186359] p 29 N88-15003
Large-angle slewing maneuvers for flexible spacecraft
[NASA-CR-4123] p 60 N88-16060
Emulating a flexible space structure Modeling
[NASA-TM-100320] p 30 N88-16812
Sensitivity of active vibration control to structural changes and model reduction p 30 N88-17683
Formulation methods of rigid multibody systems for large space structures and some results of computer simulation
[NAL-TR-942] p 30 N88-17730
Preliminary investigation of stability of a tin-stiffened slender strut
[NASA-TM-4034] p 31 N88-19568
Cost effective development of a national test bed
[NASA-TM-100321] p 31 N88-19585
Workshop on Technology Development Issues for the Large Deployable Reflector (LDR)
[NASA-CP-2407] p 32 N88-20235

LASER APPLICATIONS
Preliminary conceptual design and weight of a one-megawatt space-based laser power station utilizing a solar-pumped iodine lasant p 65 A88-11816
Laser Docking System Radar flight experiment p 47 A88-12814
Scanning laser radar system for rendezvous and docking in space
[IAF PAPER 87-52] p 48 A88-15839

LASER OUTPUTS
An amplitude modulated laser system for distance and displacement measurement p 47 A88-12813

LASER PROPULSION
Concept studies for a laser powered Orbital Transfer Vehicle
[IAF PAPER 87-200] p 77 A88-15937

LATCHES
Docking/Berthing Subsystem (DBS) Development part 1: Latching analysis — Columbus
[ESA-CR(P)-2479] p 60 N88-15825

LATTICES
Continuum modeling of large lattice structures: Status and projections
[NASA-TP-2767] p 28 N88-14115

LAUNCH VEHICLE CONFIGURATIONS
Possibilities for a European evolutionary space infrastructure
[IAF PAPER 87-68] p 105 A88-15847

LAUNCH VEHICLES
Commercial launch systems - The foreseeable future for Aussat p 161 A88-15480
The impact of launch vehicle constraints on U.S. Space Station design and operations
[IAF PAPER 87-72] p 2 A88-15848
Development scenario of H-II Orbiting Plane, HOPE
[IAF PAPER 87-210] p 48 A88-15943
New space priorities in the USSR p 138 A88-19826

LEADERSHIP
Crew productivity issues in long-duration space flight
[AIAA PAPER 88-0444] p 154 A88-22330
Space station: Leadership for the future
[NASA-PAM-509/8-87] p 165 N88-10072

LEAST SQUARES METHOD
Torturing recursive parameter identification algorithms with a gain nonlinearity
[AIAA PAPER 88-2439] p 24 A88-32356

LEGAL LIABILITY
Legal problems of the commercial use of space stations including proprietary rights p 160 A88-13452

LIAPUNOV FUNCTIONS
Lyapunov function gradient generated robust control in the absence of the nominal stabilizing control p 54 A88-27404

LIBRATION
Dynamics and control during slewing maneuvers
[IAF PAPER 87-353] p 49 A88-16043
A relatively general formulation for studying dynamics of the Space Station based MRMS with applications — Mobile Remote Manipulator System
[AIAA PAPER 88-0674] p 72 A88-22504

LIFE (DURABILITY)
High intensity 5 eV O-atom exposure facility for material degradation studies p 96 N88-10847
A life test of a 22-Newton (5-lbf) hydrazine rocket
[NASA-TM-100232] p 79 N88-11750
KBS V and V as related to automation of space station subsystems: Rationale for a KBS lifecycle p 9 N88-16375

LIFE CYCLE COSTS
STS propellant scavenging systems study. Part 2, volume 2: Cost and WBS/dictionary
[NASA-CR-179276] p 81 N88-17717

LIFE SCIENCES
Science plans and requirements for the U.S./International Space Station
[IAF PAPER 87-93] p 103 A88-15864
Accommodating life sciences on the Space Station
[SAE PAPER 871412] p 38 A88-21077
Environmental control and life support systems analysis for a Space Station life sciences animal experiment
[SAE PAPER 871417] p 39 A88-21081
Life sciences biomedical research planning for Space Station
[SAE PAPER 871464] p 153 A88-21122
Scientific objectives and functional requirements of life sciences in the Space Station p 114 A88-21570
Focus of attention in systems for visual monitoring of experiments p 112 A88-21458
Telescience testbedding for life science missions on the Space Station
[AIAA PAPER 88-0446] p 96 A88-22332
The role of preventive medicine in the future of USA space life sciences p 155 A88-29104
The space life sciences research and application in Europe p 143 A88-29106
Space life sciences in Japan p 164 A88-29107
The opportunities for space biology research on the Space Station p 155 A88-29134
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 1: Executive summary. Phase A: Conceptual design and programmatics
[NASA-CR-179268] p 104 N88-17721
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 2: Study results, attachment 2. Phase A: Conceptual design and programmatics
[NASA-CR-179272] p 46 N88-17722
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 2: Study results. Appendix E: Work breakdown structure and dictionary
[NASA-CR-179274] p 46 N88-17723
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 2: Study results. Appendix D: Life sciences research facility requirements
[NASA-CR-179273] p 46 N88-17724
Conceptual design and programmatics studies of space station accommodations for Life Sciences Research Facilities (LSRF)
[NASA-CR-179270] p 46 N88-19567
Space station accommodations for life sciences research facilities: Phase A conceptual design and programmatics studies for Missions SAAX0307, SAAX0302 and the transition from SAAX0307 to SAAX0302. Volume 1: Executive summary
[NASA-CR-179267] p 104 N88-19571
The European Space Agency's role in life sciences and research in space p 148 N88-19694
Life sciences in the framework of the ESA microgravity program and future flight opportunities p 148 N88-19695

LIFE SUPPORT SYSTEMS
Crewman rescue equipment in manned space missions - Aspects of application
[IAF PAPER 87-576] p 153 A88-16187
Environmental control and life support systems analysis for a Space Station life sciences animal experiment
[SAE PAPER 871417] p 39 A88-21081
A computer aided engineering tool for ECLS systems
[SAE PAPER 871425] p 98 A88-21087
Simulation and control of a Space Station air revitalization system
[SAE PAPER 871425] p 7 A88-21089
G189 computer program modeling of environmental control and life support systems for the Space Station
[SAE PAPER 871427] p 39 A88-21090
Environmental control and life support system for Japanese Experiment Module
[SAE PAPER 871429] p 39 A88-21092
Columbus ECLSS
[SAE PAPER 871430] p 139 A88-21093
Environmental control and life support system requirements and technology needs for advanced manned space missions
[SAE PAPER 871433] p 39 A88-21096
Lighting considerations in a controlled environmental life support system
[SAE PAPER 871435] p 39 A88-21098
Static feed electrolyzer technology advancement for space application
[SAE PAPER 871450] p 40 A88-21110
Performance evaluation of SPE electrolyzer for Space Station life support
[SAE PAPER 871451] p 40 A88-21111
Stability of IRA-45 solid amine resin as a function of carbon dioxide absorption and steam desorption cycling
[SAE PAPER 871452] p 40 A88-21112
Environmental control and life support testing at the Marshall Space Flight Center
[SAE PAPER 871453] p 40 A88-21113
Initial results of integrated testing of a regenerative ECLSS at MSFC
[SAE PAPER 871454] p 41 A88-21114
Technology demonstrator program for Space Station Environmental Control Life Support System
[SAE PAPER 871456] p 41 A88-21115
Water management requirements for animal and plant maintenance on the Space Station
[SAE PAPER 871469] p 41 A88-21125
Electrochemically regenerable carbon dioxide/moisture control technology for an Advanced Extravehicular Mobility Unit
[SAE PAPER 871470] p 41 A88-21126
Review of water disinfection techniques
[SAE PAPER 871488] p 42 A88-21142
An experimental study of the Bosch and the Sabatier CO2 reduction processes
[SAE PAPER 871517] p 43 A88-21162
Design and development of the life support subsystem of a laboratory model of the Botany Facility
[SAE PAPER 871519] p 43 A88-21164
Off to see the wizard — space suits p 164 A88-22957
The feasibility of Chlorella as the exchanger of CO2 for O2 and the food resources in the Space Station p 43 A88-29136
Solar plant growth facility (SPGF) - An approach toward future biological life support systems p 155 A88-29141
Controlled Ecological Life Support Systems (CELSS) conceptual design option study
[NASA-CR-177421] p 44 N88-14625
Development of a graphical display on the DMS test bed p 101 N88-14864
Monitoring of space station life support systems with miniature mass spectrometry and artificial intelligence p 45 N88-16376
Prototype space station automation system delivered and demonstrated at NASA p 45 N88-16442

LIGHTNING
Lighting considerations in a controlled environmental life support system
[SAE PAPER 871435] p 39 A88-21098
Astrophysics and the solar nebula p 116 N88-19355

LINEAR EQUATIONS
Transient response of joint dominated space structures - A new linearization technique
[AIAA PAPER 88-2393] p 24 A88-32325

LINEAR PROGRAMMING
Structural model verification with LQG theory — Linear Quadratic Optimization
[AIAA PAPER 88-2360] p 23 A88-32300

LINEAR QUADRATIC GAUSSIAN CONTROL
Structural design and decoupled control — of large space structures
[IAF PAPER 87-318] p 48 A88-16016
A parameter robust LQG design synthesis with applications to control of flexible structures p 15 A88-27318
Integrated control of large flexible structures p 16 A88-29474
New feedback design methodologies for large space structures: A multi-criterion optimization approach p 59 N88-12535
Design of low order controllers for robust disturbance rejection in large space structures
[AD-A185202] p 59 N88-13376
Large-angle slewing maneuvers for flexible spacecraft
[NASA-CR-4123] p 60 N88-16060

LINEAR QUADRATIC REGULATOR
An experimental study on flexible spacecraft three-axis attitude control p 53 A88-26356

LINEAR SYSTEMS
Robust stabilization under mode truncation and parameter variations p 15 A88-27325

LINKAGES
Assessment of the COFSI/MAST I project
[NASA-CR-181366] p 25 N88-10340
LIQUID FLOW
Performance characteristics of moving belt radiators --- for spacecraft applications p 33 A88-12006
LIQUID OXYGEN
A lunar transportation system
[NASA-CR-182561] p 107 N88-19379
LIQUID PROPELLANT ROCKET ENGINES
Space station resistojet system requirements and interface definition study
[NASA-CR-180832] p 80 N88-12541
LIQUID ROCKET PROPELLANTS
Space station resistojet system requirements and interface definition study
[NASA-CR-180832] p 80 N88-12541
LIQUID SLOSHING
Slosh dynamics in a toroidal tank --- for orbit transfer vehicle cryogenic propellant storage p 79 A88-27888
LIQUID WASTES
OSSA Space Station waste inventory
[SAE PAPER 871413] p 39 A88-21078
Space station resistojet system requirements and interface definition study
[NASA-CR-180832] p 80 N88-12541
LITHIUM HYDRIDES
Optimization and analysis of lithium hydride thermal energy storage device configurations for space power applications p 64 A88-11802
LOAD DISTRIBUTION (FORCES)
Automated space power distribution and load management p 67 A88-11860
Automated load management for spacecraft power systems p 67 A88-11863
LOADS (FORCES)
Assessment of the COFSI/MAST I project
[NASA-CR-181366] p 25 N88-10340
Wave propagation experiments on 22-bay lattice
[AD-A186140] p 29 N88-15002
LOGISTICS
A space transportation system operations model
[NASA-TM-100481] p 8 N88-14999
Prototype resupply scheduler p 9 N88-16429
Preliminary analysis of an integrated logistics system for OSSA payloads
[NASA-CR-4114] p 6 N88-19477
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 1: Executive summary
p 6 N88-19478
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 2: OSSA integrated logistics support strategy p 6 N88-19479
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 3: OSSA integrated logistics support planning document p 6 N88-19480
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 4: Supportability analysis of the 1.8m centrifuge p 6 N88-19481
LOGISTICS MANAGEMENT
Logistics flow for Columbus MTFF
[IAF PAPER 87-39] p 123 A88-15829
Automated Space Station procedure execution
[AIAA PAPER 88-0443] p 99 A88-22329
LONG DURATION SPACE FLIGHT
The role of psychologists in future spaceflight
p 159 A88-10958
Medical aspects of orbital spaceflight and their implications for manufacturing in space
p 38 A88-13162
Columbus pressurized modules: Maintenance and supply concepts - Approach and development for a Space Station long term support
[IAF PAPER 87-86] p 137 A88-15860
Biomedical payload of the French-Soviet long duration flight
[IAF PAPER 87-541] p 152 A88-16159
Providing artificial gravity - Physiologic limitations to rotating habitats
[IAF PAPER 87-545] p 152 A88-16163
Endurance record broken p 138 A88-18699
The opportunities for space biology research on the Space Station p 153 A88-20282
Bones and stones in space - Integrating the medical and scientific questions
[SAE PAPER 871465] p 153 A88-21123
Human exploration of Mars --- assessment of technology requirements
[AIAA PAPER 88-0064] p 105 A88-22044
Crew productivity issues in long-duration space flight
[AIAA PAPER 88-0444] p 154 A88-22330
The role of preventive medicine in the future of USA space life sciences p 155 A88-29104
Cosmonauts observe supernova p 144 A88-30189
Basic results of medical studies during prolonged manned flights on-board the Salyut-7/Soyuz-T orbital complex
[NASA-TT-20217] p 147 N88-18182
LONG TERM EFFECTS
Medical aspects of orbital spaceflight and their implications for manufacturing in space
p 38 A88-13162
Space technology to meet future needs
[NASA-CR-181473] p 106 N88-10819
Carbon Dioxide observational platform system (CO-OPS) Feasibility Study
[NASA-CR-179225] p 118 N88-14113
LOW ALTITUDE
State-of-the-art technologies for construction in space: A review
[AD-A188412] p 31 N88-19483
LOW GRAVITY MANUFACTURING
Active vibration control in microgravity environment
p 55 A88-31565
Analysis of low gravity tolerance of model experiments for space station: Preliminary results for directional solidification
[NASA-CR-182657] p 10 N88-19648
LOW SPEED
Planetary science p 5 N88-15356
LUMINESCENCE
Stratospheric luminescence observed from the Salyut-7 station p 144 A88-30076
LUNAR BASES
Project Horizon - An early study of a lunar outpost
[IAF PAPER 87-659] p 105 A88-16237
A lunar laboratory p 106 A88-29196
Space farming in the 21st century
p 106 A88-29237
Space station accommodations for lunar base elements: A study
[NASA-TM-100501] p 106 N88-14907
Critical issues for establishment of a permanently-occupied lunar base
[AD-A187128] p 107 N88-17567
LUNAR EXPLORATION
A lunar laboratory p 106 A88-29196
LUNAR LANDING MODULES
A lunar transportation system
[NASA-CR-182561] p 107 N88-19379
LUNAR SPACECRAFT
A lunar laboratory p 106 A88-29196
LUNAR SURFACE
A lunar laboratory p 103 A88-29196
Space station accommodations for lunar base elements: A study
[NASA-TM-100501] p 106 N88-14907

M

MAGNETIC BEARINGS
Application of magnetic bearings to high-torque, satellite attitude control wheels p 47 A88-11908
MAGNETIC EFFECTS
Electrodynamic tether system study
[NASA-CR-172024] p 117 N88-11737
MAGNETIC FIELDS
Computer-aided modeling and prediction of performance of the modified Lundell class of alternators in space station solar dynamic power systems
[NASA-CR-182538] p 74 N88-19000
MAGNETIC FLUX
Magnetic emissions testing of the space station engineering model resistojet
[NASA-TM-100788] p 81 N88-17728
MAGNETIC STORMS
Modeling of environmentally-induced effects within satellites. Part 1: NASCAP modeling of satellites
p 38 N88-11721
MAGNETIC SUSPENSION
Pointing mount with active vibration isolation for large payloads
[AAS PAPER 87-033] p 103 A88-16993
MAGNETO-OPTICS
NASA spaceborne optical disk recorder development
p 100 A88-29820
MAGNETOHYDRODYNAMIC WAVES
The structure of ULF waves produced by a tethered satellite system p 114 A88-23924
Alfven waves from an electrodynamic tethered satellite system p 115 A88-25890
MAGNETOPLASMADYNAMICS
Solar-thermal OTVs in comparison with electrical and chemical propulsion systems
[IAF PAPER 87-199] p 77 A88-15936
MAINTAINABILITY
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 4: Supportability analysis of the 1.8m centrifuge p 6 N88-19481
MAINTENANCE
Experience of the Salyut-7 propulsion system (PS) repair operations
[IAF PAPER 87-67] p 137 A88-15861
Space Assembly, Maintenance, and Servicing Study (SAMSS) p 125 N88-10089
Spacecraft Systems Working Group report
p 165 N88-10091
Space station assembly/servicing capabilities
p 125 N88-10100
MAN ENVIRONMENT INTERACTIONS
Solar power satellites p 70 A88-17023
MAN MACHINE SYSTEMS
Automation and robotics technology application to JEM --- Japanese Experiment Module
[IAF PAPER 87-74] p 136 A88-15849
NASA-STD-3000, Man-System Integration Standards - The new space human engineering standards
[IAF PAPER 87-550] p 152 A88-16187
Robots - Autonomous space workers
p 84 A88-19866
A dishwasher for the Space Station
[SAE PAPER 871411] p 38 A88-21076
Evolutive concept of an EVA space suit
[SAE PAPER 871518] p 154 A88-21183
An orbiting control station for free-flying teleoperators - Preliminary design methodology p 51 A88-21647
Implementation of expert system technology on the Space Station p 99 A88-21654
Impact of intelligent systems on Space Station man-machine interface (MMI) design p 85 A88-21655
Cooperative human-machine fault diagnosis
p 85 A88-21659
Third Conference on Artificial Intelligence for Space Applications, part 1
[NASA-CP-2492-Pt-1] p 89 N88-16360
Intelligent man/machine interfaces on the space station p 90 N88-16418
Crew interface with a telerobotic control station
p 91 N88-17273
The ESA/Fokker service end-effector subsystem: A robotic/man-compatible servicing approach
p 92 N88-19502
Man-tended options for European space robotics
p 94 N88-19538
OMV man/system simulation integration: A preliminary analysis and recommendation
[NASA-CR-182602] p 151 N88-20005
MAN-COMPUTER INTERFACE
Impact of intelligent systems on Space Station man-machine interface (MMI) design p 85 A88-21655
Theoretical considerations in designing operator interfaces for automated systems p 85 A88-21658
Cooperative human-machine fault diagnosis
p 85 A88-21659
Crew interface with a telerobotic control station
p 91 N88-17273
MANAGEMENT INFORMATION SYSTEMS
Science on the Space Station: The opportunity and the challenge - A NASA view
[IAF PAPER 87-92] p 98 A88-15863
MANAGEMENT PLANNING
Space Station Program implications from the viewpoint of the Space Station Operations Task Force
[IAF PAPER 87-82] p 123 A88-15858
Long range planning at NASA
[IAF PAPER 87-870] p 183 A88-16243
Human exploration of Mars --- assessment of technology requirements
[AIAA PAPER 88-0064] p 105 A88-22044
Space Construction
[NASA-CP-2490] p 26 N88-10870
Marshall Space Flight Center's role in EASE/ACCESS mission management p 27 N88-10875
An allotment planning concept and related computer software for planning the fixed satellite service at the 1988 space WARC
[NASA-TM-100244] p 165 N88-11944
MANEUVERS
Dynamics of spacecraft control laboratory experiment (SCOLE) slew maneuvers
[NASA-CR-4098] p 57 N88-10082
Analytical investigation of the dynamics of tethered constellations in Earth orbit (phase 2)
[NASA-CR-179218] p 117 N88-12533
Combined problem of slew maneuver control and vibration suppression
[NASA-CR-181537] p 59 N88-12817
MANIPULATORS
Modelling and simulation of distributed flexibility in a spaceborne manipulator p 83 A88-16309
Formulation of rigid multibody systems in space
p 14 A88-21221
Development of a master slave manipulator system for space use p 86 A88-26975

Telepresence work station system definition study, part 2
[NASA-CR-172606] p 4 N88-10071
Telerobotics p 86 N88-10090
Traction-drive seven degrees-of-freedom telerobot arm: A concept for manipulation in space
[DE87-010895] p 87 N88-10346
Modeling and control of large flexible vehicles in the atmosphere and space
[AD-A185368] p 27 N88-13377
Cartesian path control of a two-degree-of-freedom robot manipulator
[NASA-CR-182231] p 88 N88-13908
Dynamics, control and sensor issues pertinent to robotic hands for the EVA retriever system p 88 N88-14876
Goal driven kinematic simulation of flexible arm robot for space station missions p 89 N88-16388
Solid modeling for the manipulative robot arm (power) and adaptive vision control for space station missions p 89 N88-16409
Telerobotic research at NASA Langley Research Center p 91 N88-17269
Manipulator arm design for the Extravehicular Teleoperator Assist Robot (ETAR): Applications on the space station p 91 N88-17270
Telerobotic truss assembly p 91 N88-17272

MANNED MANEUVERING UNITS
Personnel occupied woven envelope robot power
[NASA-CR-182367] p 88 N88-15196

MANNED MARS MISSIONS
Aeroassisted-vehicle design studies for a manned Mars mission
[IAF PAPER 87-433] p 50 A88-16093
Manned Mars mission accomodation by the evolutionary Space Station
[IAF PAPER 87-438] p 105 A88-16097
Human exploration of Mars — assessment of technology requirements
[AIAA PAPER 88-0064] p 105 A88-22044
Two days to Mars with fusion propulsion p 78 A88-29236
Aeroassisted-vehicle design studies for a manned Mars mission
[NASA-TM-100031] p 56 N88-11700
Aeroassisted manned transfer vehicle (TAXI) for advanced Mars Transportation: NASA/USRA 1987 Senior Design Project
[NASA-CR-181478] p 106 N88-11736

MANNED ORBITAL LABORATORIES
Preparing for the future — NASA Space Station program p 159 A88-10306
Space biologist's inflight safety considerations
[IAF PAPER 87-570] p 153 A88-16182
Biotechnology opportunities on Space Station
[SAE PAPER 871468] p 154 A88-21124
Metallurgy laboratory for Columbus, executive summary
[SNIAS-813-CA/TS] p 145 N88-10980
Thermophysical Properties Measurement Facility (TPMF) — Columbus space station
[ESA-CR(P)-2417] p 8 N88-10981
A preliminary study of a fluid science laboratory for space station (Columbus). Part 4: Executive summary
[NLR-TR-87023-L/PT-4] p 79 N88-11072
Man-Tended Free Flyer operational design features p 128 N88-19485
Mission profiles of the MTFF co-orbiting with the US Space Station p 8 N88-19487
Analysis of RVD operations in manned space missions p 61 N88-19494
On a knowledge based assisted system for highly autonomous control of experiment-manipulators in the Man-Tended Free Flyer p 92 N88-19505
Microgravity User Support Center (MUSC) for EURECA, Spacelab and Columbus missions p 149 N88-19947

MANNED SPACE FLIGHT
Has manned space flight a future? p 159 A88-10850
Medical aspects of orbital spaceflight and their implications for manufacturing in space p 38 A88-13162
Looking to year 2001 p 104 A88-13974
Potentials of robotic operations on board the man-tended free-flyer
[IAF PAPER 87-17] p 82 A88-15813
Long-term evolution toward European manned spaceflight
[IAF PAPER 87-78] p 136 A88-15853
Manned Mars mission accomodation by the evolutionary Space Station
[IAF PAPER 87-438] p 105 A88-16097
Man in space flight
[IAF PAPER 87-527] p 162 A88-16150
Cosmonaut behaviour in orbital flight situation - Preliminary ethological analysis
[IAF PAPER 87-528] p 152 A88-16151
Biomedical payload of the French-Soviet long duration flight
[IAF PAPER 87-541] p 152 A88-16159
Radiation problems with the Space Station scenario and the necessary surveillance for astronauts
[IAF PAPER 87-542] p 129 A88-16160
NASA-STD-3000, Man-System Integration Standards - The new space human engineering standards
[IAF PAPER 87-550] p 152 A88-16167
The dangers of space debris - New developments and discoveries p 130 A88-18398
Endurance record broken p 138 A88-18699
Environmental control and life support system requirements and technology needs for advanced manned space missions
[SAE PAPER 871433] p 39 A88-21096
Test results of a shower water recovery system
[SAE PAPER 871512] p 42 A88-21158
Industrial Space Facility
[AIAA PAPER 88-0649] p 3 A88-22484
Space near and far — Russian book p 143 A88-27734
The role of preventive medicine in the future of USA space life sciences p 155 A88-29104
Solar plant growth facility (SPGF) - An approach toward future biological life support systems p 155 A88-29141
Mankind and space — Russian book p 164 A88-29410
USSR report: Space
[JPRS-USF-87-003] p 144 N88-10050
Progress in European CELSS activities p 44 N88-12252
National Aeronautics and Space Administration space station proposal, fiscal year 1988
[S-HRG-100-329] p 166 N88-14043
Safety philosophy, policy, and requirements for manned spaceflight. Volume 1: Executive summary
[HEG-0886/1036-VOL-1] p 157 N88-15826
Electrochemical processing of solid waste
[NASA-CR-182413] p 157 N88-15852
JPRS report: Science and technology: USSR: Space
[JPRS-USP-87-006] p 146 N88-16063
Integrity control of carbon fiber reinforced plastics (CFRP) structural elements. Conclusion with respect to the control methodology of CFRP primary structures in manned space flight and the implications to the design, analysis and testing of CFRP structural elements, executive summary
[MBB-TR-RB517-014/85] p 97 N88-16824
Study on long term evolution towards European manned space flight. Volume 1: Executive summary
[MBB-RA3-004/87-VOL-1] p 147 N88-17689
Basic results of medical studies during prolonged manned flights on-board the Salyut-7/Soyuz-T orbital complex
[NASA-TT-20217] p 147 N88-18182
Radiation problems in manned space flight with a view to the Space Station p 132 N88-19934

MANNED SPACECRAFT
Incipient fault detection and power system protection for spaceborne systems p 66 A88-11826
Spacehab - A manned Space Station testbed p 103 A88-15287
Development scenario of H-II Orbiting Plane, HOPE
[IAF PAPER 87-210] p 48 A88-15943
Artificial gravity - A countermeasure for zero gravity
[IAF PAPER 87-533] p 105 A88-16156
Crewman rescue equipment in manned space missions - Aspects of application
[IAF PAPER 87-576] p 153 A88-16187
Bioisolation on the Space Station - On mice and men
[SAE PAPER 871457] p 153 A88-21116
Spacecraft water system disinfection technology - Past, present, and future needs
[SAE PAPER 871487] p 41 A88-21141
Review of water disinfection techniques
[SAE PAPER 871488] p 42 A88-21142
Radiation hazards on space missions p 130 A88-22919
Orbital systems p 143 A88-26170
Aerothermodynamics - A key to new aerospace transport systems
[DGLR PAPER 87-077] p 4 A88-32477
Techniques for fire detection p 156 N88-12521
Space station accommodations for lunar base elements: A study
[NASA-TM-100501] p 106 N88-14907

MANUFACTURING
Spacecraft Systems Working Group report p 165 N88-10091

MARS (PLANET)
Manned Mars mission accomodation by the evolutionary Space Station
[IAF PAPER 87-438] p 105 A88-16097

MASS
Impact of thermal energy storage properties on solar dynamic space power conversion system mass p 64 A88-11805
Phase 3 study of selected tether applications in space. Volume 2: Study results
[NASA-CR-179186] p 116 N88-10828
The effect of maximum-allowable payload temperature on the mass of a multimegawatt space-based platform
[DE88-001921] p 37 N88-13381

MASS DRIVERS (PAYLOAD DELIVERY)
Ram accelerator direct launch system for space cargo
[IAF PAPER 87-211] p 162 A88-15944

MASS SPECTROMETERS
A model-free method for mass spectrometer response correction — for oxygen consumption and cardiac output calculation p 111 A88-19883

MASS SPECTROSCOPY
Monitoring of space station life support systems with miniature mass spectrometry and artificial intelligence p 45 N88-16376

MASS TRANSFER
Outgassing of spacecraft composites p 95 A88-31404

MATERIALS RECOVERY
An overview of Japanese CELSS research activities p 44 N88-12267

MATERIALS SCIENCE
Novel composite materials for space structures and systems p 10 A88-13188
Science plans and requirements for the U.S./International Space Station
[IAF PAPER 87-93] p 103 A88-15864
Looking ahead for materials and processes. Proceedings of the Eighth SAMPE (European Chapter) International Conference, La Baule, France, May 18-21, 1987 p 94 A88-20701
Toward new materials processing in space p 2 A88-21572
Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Parts 1, 2, & 3 p 21 A88-32178

MATERIALS TESTS
Fractional derivatives in the description of damping materials and phenomena p 20 A88-31589

MATHEMATICAL MODELS
Optimization of the energy systems of manned orbital stations - Mathematical modeling and selection of efficient structures — Russian book p 68 A88-15664
Deployment dynamics of accordian type of deployable solar arrays considering flexibility of closed control loops
[IAF PAPER 87-256] p 11 A88-15974
Numerical and numerical-analytical interfaces in structural thermal-dynamic interactive problems
[IAF PAPER 87-322] p 49 A88-16020
Mathematical models of flexible spacecraft dynamics - A survey of order reduction approaches p 13 A88-16293
Space Station Active Thermal Control System modeling
[AIAA PAPER 88-0473] p 36 A88-22349
A recursive pole placement method for large flexible structures p 19 A88-31587
Investigation of damping from nonlinear sleeve joints of large space structures p 56 A88-31596
Optimal on-line measurement system configuration strategies
[AIAA PAPER 88-2341] p 9 A88-32294
Structural Assembly Demonstration Experiment (SADE)
[NASA-CR-179205] p 26 N88-10868
Pinhole occulter experiment
[NASA-CR-179206] p 116 N88-11481
Teleoperator and robotics system analysis
[NASA-CR-179220] p 87 N88-12105
Stochastic model of the NASA/MSFC ground facility for large space structures with uncertain parameters: The maximum entropy approach
[NASA-CR-181489] p 27 N88-12343
Analytical investigation of the dynamics of tethered constellations in Earth orbit (phase 2)
[NASA-CR-179218] p 117 N88-12533
Optimal control of large space structures via generalized inverse matrix
[NASA-CR-182336] p 59 N88-13907
Inventory behavior at remote sites p 5 N88-14873
The dynamics and control of large flexible space structures, part 10
[NASA-CR-182426] p 29 N88-15830
Gyrostabilizer system of Kvant module p 60 N88-16099
Communications satellite systems operations with the space station. Volume 3: Supplementary technical report
[NASA-CR-180875] p 77 N88-18794
Kinetic isolation tether experiment
[NASA-CR-182458] p 120 N88-18810

192

A human performance modeling approach to intelligent decision support systems p 90 N88-17242
Computer-aided modeling and prediction of performance of the modified Lundell class of alternators in space station solar dynamic power systems
[NASA-CR-182538] p 74 N88-19000
A comparative survey of mathematical models for dynamic simulation of in-orbit manipulation operations
p 148 N88-19533
Analysis of low gravity tolerance of model experiments for space station: Preliminary results for directional solidification
[NASA-CR-182657] p 10 N88-19648

MATHEMATICAL PROGRAMMING
Optimization of actively controlled structures using goal programming techniques p 53 A88-25797
Optimum design of structures with multiple constraints
p 16 A89-28042

MATRICES (MATHEMATICS)
Simultaneous structural and control optimization via linear quadratic regulator eigenstructure assignment
p 28 N88-13622
Optimal control of large space structures via generalized inverse matrix
[NASA-CR-182336] p 59 N88-13907

MATRIX MATERIALS
Carbon fiber reinforced glass matrix composites for space based applications
[AD-A184355] p 96 N88-12546

MATRIX METHODS
A unified matrix approach applied to dynamic formulation of complex space structures with nonlinear hinge forces and torques
[IAF PAPER 87-348] p 13 A88-16038
A DMAP for updating dynamic mathematical models with measured data
[NLR-MP-86027-U] p 26 N88-10387

MAXIMUM ENTROPY METHOD
Stochastic model of the NASA/MSFC ground facility for large space structures with uncertain parameters. The maximum entropy approach
[NASA-CR-181489] p 27 N88-12343

MECHANICAL DEVICES
Mechanical design of the ac bracket package for the RETF experiment
[IFSI-87-4] p 145 N88-13379
Why mechanisms are critical to spacecraft performance p 90 N88-16737

MECHANICAL DRIVES
Why mechanisms are critical to spacecraft performance p 90 N88-16737

MECHANICAL ENGINEERING
Why mechanisms are critical to spacecraft performance p 90 N88-16737

MECHANICAL PROPERTIES
Mechanical properties characterization of composite sandwich materials intended for space antenna applications
[NASA-TM-88893] p 25 N89-10121
Natural frequencies and structural integrity assessment of large space structures
[AD-A186139] p 29 N88-15001

MEGAMECHANICS
An efficient multilevel optimization method for engineering design
[AIAA PAPER 88-2226] p 8 A88-32190

MEMBRANE STRUCTURES
Fluid loss from a puncture of a space radiator
p 72 A88-30317

MEMBRANES
Vapor compression distiller and membrane technology for water revitalization p 38 A88-17072
Thermoelectric integrated membrane evaporation subsystem testing
[SAE PAPER 871446] p 40 A88-21106
Development of a non-phase-change waste-water treatment subsystem
[SAE PAPER 871514] p 43 A88-21159

MENTAL HEALTH
Psychiatric components of a Health Maintenance Facility (HMF) on Space Station p 153 A88-20864

MERCURY VAPOR
Binary mercury/organic Rankine cycle power systems
p 63 A88-11795

MESH
The integration of a mesh reflector to a 15-foot box truss structure. Task 3: Box truss analysis and technology development
[NASA-CR-176228] p 31 N88-18941

METAL FOILS
Thermal contact conductance in the presence of thin metal foils
[AIAA PAPER 88-0466] p 35 A88-22342

METAL MATRIX COMPOSITES
Comparison of experimental techniques in the measurement of damping capacity of metal-matrix composites p 56 A88-31600

METALLURGY
Metallurgy laboratory for Columbus: executive summary
[SNIAS-813-CA/TS] p 145 N88-10980

METALS
Ignition and combustion of metals in oxygen
p 79 N88-12530

METEORITIC DAMAGE
Fluid loss from a puncture of a space radiator
p 72 A88-30317
Space Station probability of no penetration due to meteoroid and orbital debris impact
[AIAA PAPER 88-2464] p 18 A88-31387
Space environmental considerations for a long-term cryogenic storage vessel p 80 N88-15933

METEOROID HAZARDS
Fluid loss from a puncture of a space radiator
p 72 A88-30317
Space environmental considerations for a long-term cryogenic storage vessel p 80 N88-15933

METEOROID PROTECTION
Hypervelocity impact damage assessment for Space Station
[AIAA PAPER 88-2465] p 18 A88-31388
Optimization techniques applied to passive measures for in-orbit spacecraft survivability
[NASA-CR-179216] p 5 N88-12532
Space suit extravehicular hazards protection development
[NASA-TM-100458] p 157 N88-12927
Space environmental considerations for a long-term cryogenic storage vessel p 80 N88-15933
Space station integrated wall damage and penetration damage control. Task 5: Space debris measurement, mapping and characterization system
[NASA-CR-179281] p 30 N89-17608

METEOROLOGICAL SATELLITES
Japan takes charge p 143 A88-27952

METHODOLOGY
Space station operating system study
[NASA-CR-179308] p 127 N88-18619

MICE
Biosatellite on the Space Station - Of mice and men
[SAE PAPER 871457] p 153 A88-21116

MICHELSON INTERFEROMETERS
SATIRE - A novel high resolution cooled spectrometer for atmospheric research
[IAF PAPER 87-137] p 109 A88-15894
A test-bed for space interferometry: Space Platform Interferometer (SPI) p 5 N88-10640

MICROBIOLOGY
Treatment bed microbiological control
[SAE PAPER 871492] p 42 A88-21146
Inflight microbial analysis technology
[SAE PAPER 871493] p 42 A88-21147

MICROGRAVITY APPLICATIONS
Columbus pressurized modules - A challenging opportunity for microgravity research and application
[IAF PAPER 87-375] p 137 A88-16090
Spacehab's commercialization of microgravity research activities
[IAF PAPER 87-629] p 110 A88-16221
Prospects and problems in microgravity fluid science
p 2 A88-21589
The opportunities for space biology research on the Space Station p 155 A89-29134

MICROMETEOROIDS
Fluid loss from a puncture of a space radiator
p 72 A88-30317

MICROORGANISMS
Exobiology and life science p 119 N88-15358
Design concepts for bioreactors in space
p 45 N88-17179

MICROWAVE ANTENNAS
A general truss system for very large space base foundations, with application to the polar power satellite
[IAF PAPER 87-248] p 11 A88-15967
Space based nuclear microwave electric propulsion
p 78 A88-22709
Deployable umbrella reflector antennas --- Russian book p 143 A88-27743

MICROWAVE FREQUENCIES
Space based nuclear microwave electric propulsion
p 79 A88-22709

MICROWAVE RADIOMETERS
Study of a payload for Columbus Polar Platform Earth observation demonstration mission, executive summary
[ESA-CR(P)-2412] p 116 N88-10079

MICROWAVE TRANSMISSION
Proposal of adaptively controlled transmitting array for microwave power transmission in space
p 53 A88-25854

MILITARY OPERATIONS
State-of-the-art technologies for construction in space: A review
[AD-A186412] p 31 N88-19483

MILITARY SPACECRAFT
Autonomous spacecraft operations - Problems and solutions
[AIAA PAPER 87-2850] p 81 A88-12571

MILITARY TECHNOLOGY
Investigation of design concepts for large space structures to support military applications
[AD-A186098] p 29 N88-15000

MIR SPACE STATION
One mission on board the MIR Space Station - The French-Soviet project Aragatz
[IAF PAPER 87-96] p 137 A88-15867
Mir - Soviet base in space p 129 A88-16378
1987 - Very good year for Soviets
p 138 A88-16379
Endurance record broken p 138 A88-19699
The Soviet space flight project MIR
p 139 A88-20054
The high-flying Kvant module p 139 A88-20457
Cosmonauts observe supernova p 144 A88-30109
USSR report: Space
[JPRS-USP-87-003] p 144 N88-10050
Blagov commentary on Mir station, first manning
p 144 N88-10051
X-ray astronomy instruments to operate on Mir station
p 144 N88-10052
Gyrostabilizer system of Kvant module
p 60 N88-16099
Mediab: A project of a medical laboratory in space
p 159 N88-19946

MIRRORS
A novel photovoltaic power system which uses a large area concentrator mirror p 65 A88-11911
Design, analysis, fabrication and test of the LAMAR protoflight mirror assembly --- Large Area Modular Array of Reflectors p 10 A88-12719
Solar converging method p 37 N88-12504

MISSION PLANNING
Preparing for the future --- NASA Space Station program p 139 A88-10308
Long-term evolution toward European manned spaceflight
[IAF PAPER 87-79] p 136 A88-15853
AUTOPLAN - A PC-based automated mission planning tool p 7 A88-20488
PLAN-IT - Knowledge-based mission sequencing
p 7 A88-21644
Human exploration of Mars --- assessment of technology requirements
[AIAA PAPER 88-0064] p 105 A88-22044
Space power needs and forecasted technologies for the 1990s and beyond p 71 A88-22677
Space Station assembly - Techniques and structures
p 104 A88-26420
The Eurosa space platform p 143 A88-28856
Long-term strategy of space science in Japan
p 143 A88-29195
Space Station Mission Planning System (MPS) development study. Volume 2
[NASA-CR-179200] p 4 N88-10048
Space Station Mission Planning Study (MPS) development study. Volume 3: Software development plan
[NASA-CR-179203] p 4 N88-10049
Columbus preparatory program. Payload element study on a technology demonstration mission, executive summary
[CS-RP-AI-016] p 145 N88-10080
Space technology to meet future needs
[NASA-CR-181473] p 106 N88-10819
Space Construction
[NASA-CP-2400] p 26 N88-10870
The flight demonstration program and selection process p 126 N88-10871
Mission Peculiar Equipment Support Structure: A platform for space construction p 26 N88-10874
Marshall Space Flight Center's role in EASE/ACCESS mission management p 27 N88-10875
Space station systems: A bibliography with indexes
[NASA-SP-7056(05)] p 5 N88-13382
Rendezvous and Docking Verification (RVDV) and in-orbit demonstration, executive summary
[RVD-RVDV-FR-AS-01] p 127 N88-14120
Tethers in space handbook
[NASA-CR-181371] p 119 N88-14123
Controlled Ecological Life Support Systems (CELSS) conceptual design option study
[NASA-CR-177421] p 44 N88-14825
A space transportation system operations model
[NASA-TM-100481] p 9 N88-14999

Advancing automation and robotics technology for the space station and for the US economy: Submitted to the United States Congress May 15, 1987
[NASA-TM-89811] p 88 N88-15817
The 1987 Get Away Special Experimenter's Symposium
[NASA-CP-2500] p 121 N88-17691
America plans for space
[AD-A187465] p 167 N88-17713
Rendezvous and docking verification and demonstration in orbit, executive summary
[MSR-303-16/86] p 61 N88-17719
A two stage launch vehicle for use as an advanced space transportation system for logistics support of the space station
[NASA-CR-182572] p 107 N88-18606
Rendezvous and docking (RVD) verification and demonstration in-orbit p 62 N88-19531
Conceptual design and programmatics studies of space station accommodations for Life Sciences Research Facilities (LSRF)
[NASA-CR-179270] p 46 N88-19567

MOBILE COMMUNICATION SYSTEMS
Prospects on future EVA communications
[AIAA PAPER 88-0767] p 76 A88-27542

MODAL RESPONSE
Robustness of active modal damping of large flexible structures p 11 A88-13929
Structural design and decoupled control — of large space structures
[IAF PAPER 87-318] p 48 A88-16019
A unified matrix approach applied to dynamic formulation of complex space structures with nonlinear hinge forces and torques
[IAF PAPER 87-348] p 13 A88-16038
Dynamics and control during slewing maneuvers
[IAF PAPER 87-353] p 49 A88-16043
Development of the Mast Flight System linear dc motor inertial actuator
[AAS PAPER 87-021] p 13 A88-16990
Identification and control of flexible structures p 54 A88-27768
Some experiences with the Eigensystem Realization Algorithm p 17 A88-29815
Measurement and modeling of joint damping in space structures
[AIAA PAPER 88-2449] p 17 A88-31378
Spillover stabilization of large space structures
[AIAA PAPER 88-2494] p 55 A88-31393
Convergence properties of modal costs for certain distributed parameter systems p 20 A88-31570
A general approach to modal analysis for time-varying systems
[AIAA PAPER 88-2356] p 23 A88-32296
Three parallel computation methods for structural vibration analysis
[AIAA PAPER 88-2391] p 24 A88-32323
Survey of parameter estimation methods in experimental modal analysis p 24 A88-32718
Viscous damped space structure for reduced jitter p 28 N88-13623

MODELS
Approaches and possible improvements in the area of multibody dynamics modeling
[NASA-CR-179227] p 28 N88-14067
A space transportation system operations model
[NASA-TM-100481] p 8 N88-14999
Development of an emulation-simulation thermal control model for space station application
[NASA-CR-182409] p 37 N88-15823
Emulating a flexible space structure: Modeling
[NASA-TM-100320] p 30 N88-16812

MODEMS
High data rate modem simulation for the space station multiple-access communications system p 101 N88-14870

MODULARITY
Multimission Modular Spacecraft (MMS): A serviceable design spacecraft p 6 N88-19501

MODULES
Columbus pressurized module verification p 145 N88-10842

MODULUS OF ELASTICITY
Carbon fiber reinforced glass matrix composites for space based applications
[AD-A184355] p 96 N88-12548

MOISTURE CONTENT
Electrochemically regenerable carbon dioxide/moisture control technology for an Advanced Extravehicular Mobility Unit
[SAE PAPER 871470] p 41 A88-21120

MOLTEN SALTS
Fluoride salts and container materials for thermal energy storage applications in the temperature range 973 - 1400 K p 32 A88-11804

MOMENTUM
Predictive momentum management for a space station measurement and computation requirements
[NASA-CR-172026] p 58 N88-10866

MONITORS
Rapid toxicity detection in water quality control utilizing automated multispecies biomonitoring for permanent space stations p 44 N88-10848
Monitoring of space station life support systems with miniature mass spectrometry and artificial intelligence p 45 N88-16376

MONOPROPELLANTS
Orbital Spacecraft Consumables Resupply System (OSCRS): Monopropellant application to space station and OMV automatic refueling impacts of an ELV launch, volume 4
[NASA-CR-172029] p 126 N88-11741

MOON
A lunar laboratory p 106 A88-29196

MORPHOLOGY
Experimental assembly of structures in EVA: Hardware morphology and development issues p 26 N88-10872
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment p 145 N88-12917

MOTION SIMULATION
Motion simulation for in-orbit operations p 62 N88-19514

MOTION SIMULATORS
EPOS: European Proximity Operations Simulator p 147 N88-19515
Dynamic testing of a docking system — ground-based simulator p 62 N88-19516

MULTIPLE ACCESS
High data rate modem simulation for the space station multiple-access communications system p 101 N88-14870

MULTISPECTRAL RADAR
Earth science missions for the Space Station p 111 A88-17039

MUSCLES
Bones and stones in space - Integrating the medical and scientific questions
[SAE PAPER 871465] p 153 A88-21123

N

NASA PROGRAMS
NASA's Telerobotics R & D Program - Status and future directions
[IAF PAPER 87-24] p 92 A88-15816
The NASA telerobot technology demonstrator p 95 A88-21651
Space technology to meet future needs
[NASA-CR-181475] p 106 N88-10819
Report from the MPP Working Group to the NASA Associate Administrator for Space Science and Applications
[NASA-TM-87819] p 100 N88-11402
National Aeronautics and Space Administration Authorization Act, 1988
[PUB-LAW-100-147] p 165 N88-12422
Department of Housing and Urban Development-Independent Agencies Appropriations for fiscal year 1988, Thursday, 9 April 1987 National Aeronautics and Space Administration p 166 N88-12424
Department of Housing and Urban Development-Independent Agencies Appropriations for fiscal year 1988, Friday, 10 April 1987 National Aeronautics and Space Administration p 166 N88-12425
National Aeronautics and Space Administration space station proposal, fiscal year 1988
[S-HRG-100-329] p 166 N88-14043
The 1988 NASA (National Aeronautics and Space Administration) authorization
[GPO-80-245] p 166 N88-14044
The 1988 National Aeronautics and Space Administration (NASA) authorization
[GPO-78-600] p 166 N88-14854
National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987, Volume 1
[NASA-CR-172009-VOL-1] p 166 N88-14855
Report of the Committee on the Space Station of the National Research Council
[NASA-CR-181602] p 167 N88-17727
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 1: Executive summary p 6 N88-19478
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 2: OSSA integrated logistics support strategy p 6 N88-19479
Research and technology, 1987
[NASA-TM-100323] p 167 N88-20253

NASA SPACE PROGRAMS
Preparing for the future — NASA Space Station program p 159 A88-10366
Space Station careens past all obstacles p 159 A88-10367
Incipient fault detection and power system protection for spaceborne systems p 66 A88-11826
Allocating energy to experiments on the Space Station p 66 A88-11828
Research opportunities in microgravity science and applications during Shuttle hiatus p 108 A88-13164
Building intelligent systems - Artificial intelligence research at NASA Ames Research Center p 82 A88-15300
Pathfinder technologies for bold new missions — U.S. research and development program for space exploration
[IAF PAPER 87-46] p 1 A88-15832
NASA and the Space Station - Current Status
[IAF PAPER 87-64] p 161 A88-15843
United States Space Station technical and programmatic interfaces
[IAF PAPER 87-65] p 162 A88-15844
Selected advanced technology studies for the U.S. Space Station — waste water reclamation, module design and fabrication
[IAF PAPER 87-79] p 2 A88-15854
The United States Space Station revised baseline
[IAF PAPER 87-81] p 162 A88-15855
Science on the Space Station: The opportunity and the challenge - A NASA view
[IAF PAPER 87-92] p 98 A88-15863
Project Horizon - An early study of a lunar outpost
[IAF PAPER 87-459] p 105 A88-16237
Long range planning at NASA
[IAF PAPER 87-670] p 163 A88-16243
Solar power satellites - Still in the dark p 70 A88-19002
Life sciences biomedical research planning for Space Station
[SAE PAPER 871464] p 153 A88-21122
Principles of operations cooperation between the United States and Europe p 141 A88-21564
NASA Systems Autonomy Demonstration Program - A step toward Space Station automation p 84 A88-21839
Spaceward ho — U.S. and Soviet space programs
[AIAA PAPER 88-0150] p 163 A88-22587
The civil space program: An investment in America - Report of an AIAA Workshop p 164 A88-23925
Columbus preparatory program: Payload element study on a technology demonstration mission, executive summary
[CS-RP-AI-016] p 145 N88-10080
Space station: National Aeronautics and Space Administration's 1987 cost estimate
[PB87-220760] p 165 N88-10883
An overview of the current Earth observation programs (Europe, USA, and Japan) p 167 N88-16778
America plans for space
[AD-A187465] p 167 N88-17713
Columbus feasibility studies. Volume 4: Integration, test, and operations
[ETN-88-90576] p 147 N88-18614
NASA Office of Space Flight (OSF) in-orbit servicing program p 129 N88-19498

NASTRAN
An application of MSC/NASTRAN in the interdisciplinary analysis of large space-based structures p 17 A88-29819

NATURAL LANGUAGE (COMPUTERS)
Intelligent man/machine interfaces on the space station p 90 N88-16418

NAVIGATION
Guidance and control 1987; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Jan. 31-Feb. 4, 1987 p 51 A88-16976

NEAR FIELDS
A near field test system for very large antennas p 13 A88-17580

NETWORK CONTROL
Network management for the Space Station Information System
[AIAA PAPER 88-0118] p 93 A88-22082
Survey on large scale system control methods
[NASA-CR-181556] p 59 N88-13974

NETWORK SYNTHESIS
Design techniques for 20K Hz power converters p 68 A88-11822

NEURAL NETS
Dynamics, control and sensor issues pertinent to robotic hands for the EVA retriever system p 88 N88-14876

NEUTRAL BUOYANCY SIMULATION
Shuttle based assembly of Space Station
[AIAA PAPER 88-2452] p 125 A88-31379
Astronaut/EVA construction of Space Station
[AIAA PAPER 88-2-59] p 125 A88-31382
Structural Assembly Demonstration Experiment (SADE)
[NASA-CR-179205] p 26 N88-10868
Research and development at the Marshall Space Flight Center Neutral Buoyancy Simulator p 5 N88-10878
EASE (Experimental Assembly of Structures in EVA) overview of selected results p 12 N88-10881
NEWTON SECOND LAW
Motion perturbations of a dumbbell in a central Newtonian force field p 47 A88-11235
A comparative survey of mathematical models for dynamic simulation of in-orbit manipulation operations p 148 N88-19533
NEWTON THEORY
Some considerations on measuring the Newtonian gravitational constant G in an orbiting laboratory p 119 N88-15603
NICKEL HYDROGEN BATTERIES
Parametrics of nickel-hydrogen cell design -- for earth orbit vehicles p 75 A88-11912
NOAA SATELLITES
An overview of the current Earth observation programs (Europe, USA, and Japan) p 167 N88-16776
NOISE MEASUREMENT
The role of damping in vibration and noise control; Proceedings of the Eleventh Biennial Conference on Mechanical Vibration and Noise, Boston, MA, Sept. 27-30, 1987 p 20 A88-31573
NOISE SPECTRA
Torturing recursive parameter identification algorithms with a gap nonlinearity
[AIAA PAPER 88-2439] p 24 A88-32356
NONDESTRUCTIVE TESTS
Monitoring elastic stiffness degradation in graphite/epoxy composites p 14 A88-19173
Nondestructive construction error detection in large space structures
[AIAA PAPER 88-2460] p 19 A88-31393
Natural frequencies and structural integrity assessment of large space structures
[AD-A186139] p 29 N88-15001
Method of radiographic inspection of wooden members
[NASA-CASE-LAR-13724-1] p 149 N88-23983
NONLINEAR EQUATIONS
Effect of joint damping and joint nonlinearity on the dynamics of space structures
[AIAA PAPER 88-2480] p 57 A88-32362
NONLINEAR SYSTEMS
On local state feedback and stability domain estimation of nonlinear large scale systems p 144 A88-29245
Estimation and identification of nonlinear dynamic systems
[AIAA PAPER 88-2271] p 57 A88-32227
Torturing recursive parameter identification algorithms with a gap nonlinearity
[AIAA PAPER 88-2439] p 24 A88-32356
NUCLEAR ELECTRIC POWER GENERATION
Space nuclear power systems 1986; Proceedings of the Third Symposium, Albuquerque, NM, Jan. 13-16, 1986 p 71 A88-22676
NUCLEAR ELECTRIC PROPULSION
Space based nuclear-microwave electric propulsion p 78 A88-22708
NUCLEAR FUSION
Two days to Mars with fusion propulsion p 78 A88-29236
NUCLEAR POWER REACTORS
Coaxial tube array space transmission line characterization p 75 A88-11865
Particle bed reactor propulsion vehicle performance and characteristics as an orbital transfer rocket p 78 A88-22707
NUCLEAR PROPULSION
Solar- and nuclear electric propulsion for high energy orbits
[IAF PAPER 87-198] p 77 A88-15937
Space nuclear power systems 1986; Proceedings of the Third Symposium, Albuquerque, NM, Jan. 13-16, 1986 p 71 A88-22676
Two days to Mars with fusion propulsion p 78 A88-29236
NUCLEAR ROCKET ENGINES
Particle bed reactor propulsion vehicle performance and characteristics as an orbital transfer rocket p 78 A88-22707
NUCLEATION
Astrophysics and the solar nebula p 118 N88-15355
Atmospheric science p 5 N88-15357
NUMERICAL ANALYSIS
Theoretical principles of the optimal control of flexible spacecraft -- Russian book p 47 A88-10050
Numerical analysis of interaction of a high-voltage solar array with ionospheric plasma p 72 A88-27886
Dispersion, damping and confinement of propagating pulses in large space structures
[AIAA PAPER 88-2311] p 22 A88-32259
Natural control of flexible space structures p 58 N88-12534
NUMERICAL CONTROL
Telerobotics p 86 N88-19090
NUTRITIONAL REQUIREMENTS
The determination of nutritional requirements for Safe Haven Food Supply System (emergency/survival foods) p 45 N88-14956

O

OCEAN BOTTOM
Observations of ocean and sea bottom relief from space p 143 A88-26099
OCEANOGRAPHIC PARAMETERS
Observations of ocean and sea bottom relief from space p 143 A88-26099
Technical aspects of future ocean colour remote sensing p 119 N88-16298
OFF-ON CONTROL
Control design challenges of large space systems and spacecraft control laboratory experiment (SCOLE)
[NASA-CR-178392] p 58 N88-11735
ON-LINE SYSTEMS
Optimal on-line measurement system configuration strategies
[AIAA PAPER 88-2361] p 9 A88-32284
ONBOARD DATA PROCESSING
Applicability of AI techniques to the Space Station, a study case - Development of an expert system for on-board fault management
[IAF PAPER 87-30] p 83 A88-15822
Development of on-board satellite communications equipment in the Geostationary Platform era
[IAF PAPER 87-495] p 110 A88-16136
Lowering the costs of satellite operations - Lessons learned from the Solar Mesosphere Explorer (SME) mission
[AIAA PAPER 88-0549] p 7 A88-22412
Study of fault tolerant techniques for satellite data handling
[FTT/REP/0001/SAAB] p 101 N88-13860
Expert system study for spacecraft management
[TL-2699-ISS-1] p 101 N88-15004
ONBOARD EQUIPMENT
An assessment of clinical chemical sensing technology for potential use in space station health maintenance facility
[NASA-CR-172013] p 156 N88-12926
OPERATING COSTS
LERC power system autonomy program 1990 demonstration p 67 A88-11861
Lowering the costs of satellite operations - Lessons learned from the Solar Mesosphere Explorer (SME) mission
[AIAA PAPER 88-0549] p 7 A88-22412
OPERATING SYSTEMS (COMPUTERS)
Space station operating system study
[NASA-CR-179308] p 127 N88-19619
OPERATIONS RESEARCH
An overview of space station operations
[SAE SP-697] p 122 A88-15575
International Space Station operations: New dimensions - October 13, 1987
[IAF PAPER 87-13] p 122 A88-15810
Space Station Program implications from the viewpoint of the Space Station Operations Task Force
[IAF PAPER 87-62] p 123 A88-15856
Trades and problems in the definition of the Columbus operation concept
[IAF PAPER 87-83] p 136 A88-15857
Development of an automated checkout, service, and maintenance system for an EVAS Space Station
[SAE PAPER 871497] p 124 A88-21149
Telescience testbedding for life science missions on the Space Station
[AIAA PAPER 88-0448] p 99 A88-22332
An operations concept for the Space Station-based Astrometric Telescope Facility
[AIAA PAPER 88-0447] p 113 A88-22333
Potential applications of expert systems and operations research to space station logistics functions
[NASA-CR-180475] p 67 N88-12042
Inventory behavior at remote sites p 5 N88-14973
OPERATOR PERFORMANCE
A human performance modelling approach to intelligent decision support systems p 90 N88-17242
OMV man/system simulation integration: A preliminary analysis and recommendation
[NASA-CR-182602] p 151 N88-20005
OPTICAL COUPLING
An optically tethered and controlled satellite system
[IAF PAPER 87-50] p 109 A88-15835
OPTICAL DISKS
Spaceborne optical disk controller development p 96 A88-12755
NASA spaceborne optical disk recorder development p 100 A88-29620
OPTICAL MEASUREMENT
Optical measurements pertaining to Space Station solar dynamic power systems
[IAF PAPER 87-229] p 69 A88-15954
OPTICAL PROPERTIES
Astrophysics and the solar nebula p 118 N88-15355
OPTICAL RADAR
Scanning laser radar system for rendezvous and docking in space
[IAF PAPER 87-53] p 49 A88-15838
OPTICAL WAVEGUIDES
Optical fiber waveguides for spacecraft applications p 95 A88-21618
OPTIMAL CONTROL
Theoretical principles of the optimal control of flexible spacecraft -- Russian book p 47 A88-10050
On the modeling and control of a flexible manipulator arm by point actuators p 52 A88-14996
A free-flying power plant for a manned space station p 70 A88-16308
A homotopy algorithm for solving the optimal projection equations for fixed-order dynamic compensation - Existence, convergence and global optimality p 16 A88-27401
(M,N) approximation - A system simplification method p 54 A88-27402
Control-augmented structural synthesis
[AIAA PAPER 88-1014] p 55 A88-28043
A recursive pole placement method for large flexible structures p 19 A88-31587
System identification of flexible structures
[AIAA PAPER 88-2361] p 23 A88-32301
Stochastic model of the NASA/MSFC ground facility for large space structures with uncertain parameters: The maximum entropy approach
[NASA-CR-181489] p 27 N88-12343
OPTIMIZATION
Optimization and analysis of lithium hydride thermal energy storage device configurations for space power applications p 64 A88-11802
Parametrics of nickel-hydrogen cell design -- for earth orbit vehicles p 75 A88-11912
Optimization of the energy systems of manned orbital stations - Mathematical modeling and selection of efficient structures -- Russian book p 68 A88-15884
A technique to aid in the design of optimal robots for use in space applications p 85 A88-21648
Optimization of actively controlled structures using goal programming techniques p 53 A88-25797
Synthesis of the flexible structures of complex systems p 15 A88-27149
Optimal on-line measurement system configuration strategies
[AIAA PAPER 88-2361] p 8 A88-32284
New feedback design methodologies for large space structures: A multi-criterion optimization approach p 59 N88-12535
Design of low order controllers for robust disturbance rejection in large space structures
[AD-A185202] p 59 N88-13076
Simultaneous structural and control optimization via linear quadratic regulator eigenstructure assignment p 29 N88-13622
ORBIT CALCULATION
Mission profiles of the MTFF co-orbiting with the US Space Station p 6 N88-19487
ORBIT DECAY
Mission profiles of the MTFF co-orbiting with the US Space Station p 6 N88-19487
ORBIT PERTURBATION
Electrodynamic tether system study
[NASA-CR-172024] p 117 N88-11737
ORBIT TRANSFER VEHICLES
The Aeroassist Flight Experiment
[IAF PAPER 87-***] p 2 A88-15834
Solar- and nuclear electric propulsion for high energy orbits
[IAF PAPER 87-198] p 77 A88-15835
Solar-thermal OTVs in comparison with electrical and chemical propulsion systems
[IAF PAPER 87-199] p 77 A88-15836
Concept studies for a laser powered Orbital Transfer Vehicle
[IAF PAPER 87-200] p 77 A88-15837

Optimal time free nodal transfers between elliptical orbits
[IAF PAPER 87-325] p 79 A88-16221
Aeroassisted orbital transfer vehicle guidance performance in the presence of density dispersions
[AIAA PAPER 88-0302] p 150 A88-22217
Particle bed reactor propulsion vehicle performance and characteristics as an orbital transfer rocket
p 78 A88-22707
Space based nuclear microwave electric propulsion
p 78 A88-22708
High-energy orbit refueling for orbital transfer vehicles
p 150 A88-27887
Sloth dynamics in a toroidal tank --- for orbit transfer vehicle cryogenic propellant storage p 78 A88-27888
Effect of rotating earth for analysis of aeroassisted orbital transfer vehicles p 3 A88-28257
Reusable space systems (Eugen Saenger Lecture, 1987) p 125 A88-32476
Aeroassisted vehicle design studies for a manned Mars mission
[NASA-TM-100031] p 58 N88-11700
Aeroassisted manned transfer vehicle (TAXI) for advanced Mars Transportation NASA/USRA 1987 Senior Design Project
[NASA-CR-181478] p 106 N88-11736
Study of fault tolerant techniques for satellite data handling
[FTT/REP/0001/SAAB] p 101 N88-13860
An analysis of the effect of aeroassist maneuvers on orbital transfer vehicle performance
[NASA-TM-89117] p 150 N88-14116
AF cryogenic and fluid management spacecraft technology program p 60 N88-15825
SAMSS: An in-progress review of the Spacecraft Assembly, Maintenance, and Servicing Study
p 127 N88-15930
Orbital transfer vehicle studies overview
p 150 N88-15931
Large capacity cryopropellant orbital storage facility
p 60 N88-15932
Orbiter transfer vehicle concept definition and system analysis study. Volume 4: Space station accommodations. Revision 1
[NASA-CR-179293] p 150 N88-18609
Orbital transfer vehicle concept definition and system analysis study. Volume 4, Appendix A: Space station accommodations, Revision 1
[NASA-CR-179294] p 150 N88-18610
A lunar transportation system
[NASA-CR-182561] p 107 N88-19379
Automatic in-orbit payload deployment mechanisms, logistic operations and transport vehicle design compatibilities p 92 N88-19493
Aeroassisted orbit transfer vehicle trajectory analyses
[NASA-TM-89138] p 62 N88-19575

ORBITAL ASSEMBLY

A new Italian proposal for a Space Station Assembly and Servicing Vehicle (ASMV)
[IAF PAPER 87-37] p 135 A88-15827
Assembling, maintaining and servicing Space Station
[IAF PAPER 87-40] p 123 A88-15959
Assembling the Space Station p 123 A88-20475
Automatic planning research applied to orbital construction p 124 A88-21637
System architecture for telerobotic servicing and assembly tasks p 85 A88-21649
Canada's Space Station Program p 142 A88-24980
Space Station assembly - Techniques and structures
p 104 A88-26420
Shuttle based assembly of Space Station
[AIAA PAPER 88-2452] p 125 A88-31379
Design and development of the truss assembly fixture for Space Station assembly operations
[AIAA PAPER 88-2457] p 18 A88-31380
EVA construction and repair of tubular systems on Space Station
[AIAA PAPER 88-2458] p 125 A88-31381
Astronaut/EVA construction of Space Station
[AIAA PAPER 88-2459] p 125 A88-31382
Potential for on-orbit manufacture of large space structures using the pultrusion process
[NASA-TM-4016] p 28 N88-13388
Definition and economic evaluation of Space Solar Power Systems (SSPS), part 2
[ILR-MITT-184-7(1987)] p 73 N88-16190
Planning and scheduling for robotic assembly
p 90 N88-16416
ESA Bulletin No. 25
[ISSN-0376-4265] p 146 N88-16787
Satellite assembly in geostationary orbit: A plug-and-socket concept p 127 N88-16789
Space station structures development
[NASA-CR-179261] p 30 N88-16792
Telerobotic truss assembly p 91 N89-17272
Assessment of mixed fleet potential for space station launch and assembly
[NASA-TM-100550] p 107 N88-19608
Orbital transfer vehicle concept definition and system analysis study. Volume 4, Appendix A: Space station accommodations, Revision 1
[NASA-CR-179294] p 150 N88-19610
State-of-the-art technologies for construction in space: A review
[AD-A188412] p 31 N88-19483
Proceedings of the 1st European In-Orbit Operations Technology Symposium
[ESA-SP-272] p 129 N88-19484
Assembly of user systems at Space Station
p 121 N88-19490
In-orbit automatic assembly of reticular structures
p 92 N88-19491
Assembly and servicing of a European Space Station
p 147 N88-19492
A knowledge-based approach for sensory-controlled assembly operations p 128 N88-19506
Remote manipulation in orbital construction, servicing and repair missions: Is one arm enough? A comparative evaluation of the performance features of robots with one or more arms p 93 N88-19509
Utilization of robotics and teleoperation for future in-orbit operations p 93 N88-19527
External payload servicing: Operational requirements and technology p 129 N88-19541

ORBITAL LAUNCHING

Department of Housing and Urban Development-Independent Agencies Appropriations for fiscal year 1988. Thursday, 9 April 1987. National Aeronautics and Space Administration
p 166 N88-12424

ORBITAL LIFETIME

Orbit lifetime characteristics for Space Station
[AIAA PAPER 88-2490] p 55 A88-31389

ORBITAL MANEUVERING VEHICLES

Translaboring from Space Shuttle to Space Station on-orbit servicing p 121 A88-15290
OMV servicing missions from Space Station
p 121 A88-15291
Orbital Spacecraft Consumables Resupply System
p 122 A88-15292
Orbital Maneuvering Vehicle - New capability
[IAF PAPER 87-194] p 149 A88-15931
Orbital Maneuvering Vehicle (OMV) propulsion subsystem
[IAF PAPER 87-261] p 149 A88-15976
Reusable space systems (Eugen Saenger Lecture, 1987) p 125 A88-32476
Telepresence work station system definition study, part 2
[NASA-CR-172006] p 4 N88-10071
Orbital Spacecraft Consumables Resupply System (OSCRS). Volume 4: Extended study results
[NASA-CR-172012] p 126 N88-11686
Orbital Spacecraft Consumables Resupply System (OSCRS): Monopropellant application to space station and OMV automatic refueling impacts of an ELV launch, volume 4
[NASA-CR-172029] p 126 N88-11741
Teleoperator and robotics system analysis
[NASA-CR-179220] p 87 N88-12105
Orbital Spacecraft Consumables Resupply System (OSCRS): Volume 1: Executive summary
[NASA-CR-172010] p 126 N88-13368
Servicer system demonstration plan and capability development
[NASA-CR-179248] p 127 N88-15895
OMV man/system simulation integration: A preliminary analysis and recommendation
[NASA-CR-182602] p 151 N88-20005

ORBITAL MANEUVERS

Optimal trajectories for aeroassisted, noncoplanar orbital transfer. II - LEO-to-LEO transfer
[IAF PAPER 87-329] p 49 A88-16024
Control techniques for rendezvous and docking
p 51 A88-16311
Study of Plasma Motor Generator (PMG) tether system for orbit reboost
[NASA-CR-172016] p 117 N88-12501

ORBITAL MECHANICS

Coorbitation of free-flyers
[IAF PAPER 87-14] p 108 A88-15811
The incredibly versatile space tether
p 114 A88-24454
Adaptive control of Large Space Structure (LSS)
[ISAS-R-621] p [illegible] N88-11740
An analysis of the effect of aeroassist maneuvers on orbital transfer vehicle performance
[NASA-TM-89117] p 150 N88-14116
Simulation and tests of a satellite attitude and orbit control system: General considerations concerning an example case (INPE) and design of a servo rate table
[INPE-4282-PRE/1154] p 62 N88-19572

ORBITAL RENDEZVOUS

Proceedings of the 1st European In-Orbit Operations Technology Symposium
[ESA-SP-272] p 129 N88-19484
Safe rendezvous approach to a space station by impulsive transfers and continuous thrust arcs
p 151 N88-19486
Safe and fuel minimum reference trajectories for closed loop controlled approaches --- space stations
p 61 N88-19488
Analysis of RVD operations in manned space missions
p 61 N88-19494
Rendezvous and docking (RVD) verification and demonstration in-orbit p 62 N88-19531

ORBITAL SERVICING

Semiautonomous control for satellite servicing
[AIAA PAPER 87-2852] p 91 A88-12573
Satellite servicing in the Space Station era
p 121 A88-15288
Translaboring from Space Shuttle to Space Station on-orbit servicing p 121 A88-15290
OMV servicing missions from Space Station
p 121 A88-15291
MTFF operational design features
p 134 A88-15296
A Pallet-based space program for Australia
p 122 A88-15521
An overview of the Office of Space Flight satellite servicing program plan
[IAF PAPER 87-35] p 122 A88-15825
Technology advancements for servicing of future spacecraft systems
[IAF PAPER 87-36] p 122 A88-15826
A new Italian proposal for a Space Station Assembly and Servicing Vehicle (ASMV)
[IAF PAPER 87-37] p 135 A88-15827
Hubble Space Telescope servicing - Experience base for a new era
[IAF PAPER 87-39] p 109 A88-15829
On-orbit servicing and cost effectiveness of Columbus polar platform concepts
[IAF PAPER 87-42] p 123 A88-15831
The Aeroassist Flight Experiment
[IAF PAPER 87-197] p 2 A88-15834
A conceptual design for a single-stage-to-orbit Space Station Service Vehicle
[IAF PAPER 87-ST-07] p 2 A88-16071
Control of in-orbit space manipulation
p 51 A88-16312
Control aspects of a European space manipulator system p 93 A88-16313
Robots - Autonomous space workers
p 84 A88-[illegible]
On-orbit servicing enhancements with Crewlock EVA operations from the Spacehab module
[SAE PAPER 871498] p 124 A88-21148
New tools for EVA operations
[SAE PAPER 871499] p 124 A88-21150
European retrievable carrier Eureca servicing by Hermes p 139 A88-21258
The Resource Module p 140 A88-21559
A technique to aid in the design of optimal robots for use in space applications p 95 A88-21648
System architecture for telerobotic servicing and assembly tasks p 85 A88-21649
Computing architecture for telerobots in earth orbit
p 99 A88-21650
The Solar Maximum Mission repair - Lessons learned
p 124 A88-21653
Video-based satellite attitude determination
p 51 A88-21657
The GSFC Flight Support System for on-orbit satellite servicing
[AIAA PAPER 88-0448] p 124 A88-22334
Man Tended Free Flyer configurations and servicing scenarios
[MSD-UR-E-084-87] p 125 A88-23990
Canada's Space Station Program p 142 A88-24980
High-energy orbit refueling for orbital transfer vehicles
p 150 A88-27887
EVA construction and repair of tubular systems on Space Station
[AIAA PAPER 88-2458] p 125 A88-31381
Damage detection and location in large space trusses
[AIAA PAPER 88-2481] p 18 A88-31384
Space Station pressure wall repair techniques
[AIAA PAPER 88-2488] p 19 A88-31397
Telepresence work station system definition study, part 2
[NASA-CR-172006] p 4 N88-10071

Robotic sensors and actuators for a service manipulator system. Volume 1: Executive summary
[MATRA-EPT/DT/VT197/120] p 67 N88-10341
Robotic sensors and actuators for a service manipulator system. Volume 2: Service Manipulator System (SMS) handbook
[MATRA-EPT/DT/VT197/227] p 67 N88-10342
Robotic sensors and actuators for a service manipulator system. Volume 3, phase A report and program plan
[MATRA-EPT/DT/VT197/229] p 67 N88-10343
Teleoperation and control study — orbital servicing
[SAE-TP-8268] p 67 N88-10489
Orbital Spacecraft Consumables Resupply System (OSCRS). Volume 4: Extended study results
[NASA-CR-172012] p 126 N88-11686
Orbital Spacecraft Consumables Resupply System (OSCRS): Monopropellant application to space station and OMV automatic refueling impacts of an ELV launch, volume 4
[NASA-CR-172029] p 126 N88-11741
Payload configurations and serviceability — Columbus Polar Platforms p 117 N88-12133
Space station resupply system requirements and interface definition study
[NASA-CR-180832] p 80 N88-12541
Orbital Spacecraft Consumables Resupply System (OSCRS). Volume 1: Executive summary
[NASA-CR-172010] p 126 N88-13368
Servicer system demonstration plan and capability development
[NASA-CR-178246] p 127 N88-15895
Proceedings of the 1st European In-Orbit Operations Technology Symposium
[ESA-SP-272] p 126 N88-19484
Man-Tended Free Flyer operational design features p 128 N88-19485
Cost-effective orbit transfer modes for satellite retrieval and servicing — Space Station p 61 N88-19493
Assembly of user systems at Space Station p 121 N88-19490
Assembly and servicing of a European Space Station p 147 N88-19492
NASA Office of Space Flight (OSF) in-orbit servicing program p 128 N88-19498
In-orbit and laboratory exchange of ORUs designed/not designed for servicing p 101 N88-19499
Utilization of SMS and EVA for the servicing of European Space Station p 147 N88-19500
Multimission Modular Spacecraft (MMS): A serviceable design spacecraft p 6 N88-19501
The ESA/Fokker service end-effector subsystem: A robotic/man-compatible servicing approach p 92 N88-19502
Customer concerns regarding satellite servicing p 128 N88-19503
Remote manipulation in orbital construction, servicing and repair missions: Is one arm enough? A comparative evaluation of the performance features of robots with one or more arms p 93 N88-19509
Remote repair demonstration of Solar Maximum main electronics box p 128 N88-19510
Treatment of unforeseen situations by online knowledge-based diagnostic systems — spacecraft maintenance p 93 N88-19511
EPOS: European Proximity Operations Simulation p 147 N88-19515
EUROSIM: A design concept for an in-orbit operations simulator p 148 N88-19517
Explorer Platform on-orbit servicing operations p 121 N88-19526
Utilization of robotics and teleoperation for future in-orbit operations p 93 N88-19527
Review of commercial spacecraft: Recovery and repair experiences. Implications for future spacecraft designs and operations p 128 N88-19528
Robotics servicing experiment — European space programs p 93 N88-19529
Technology requirements for telerobotic satellite servicing in space p 93 N88-19536
A teleoperated manipulator system concept for unmanned platforms — Columbus p 94 N88-19537
External payload servicing: Operational requirements and technology p 129 N88-19541

ORBITAL SHOTS
Capture-ejector satellites p 108 A88-11726

ORBITAL SPACE TESTS
The in-orbit technology demonstration programme of the European Space Agency
[IAF PAPER 87-03] p 135 A88-15803

ORBITAL VELOCITY
Capture-ejector satellites p 108 A88-11726

ORBITAL WORKERS
Implications of shiftwork in space for human physiology experiments p 129 N88-19942

ORGANIC COMPOUNDS
Vapor transport furnace for organic crystals and films
[AIAA PAPER 88-0160] p 113 A88-22113

ORGANIC COOLANTS
Toluene stability Space Station Rankine power system p 63 A88-11794
Binary mercury/organic Rankine cycle power systems p 63 A88-11795

ORGANIC LIQUIDS
Solar dynamic organic Rankine cycle heat rejection system simulation p 65 A88-11808

ORGANIC MATERIALS
Exobiology and life science p 118 N88-15356

ORTHOGONALITY
Mode shape identification and orthogonalization
[AIAA PAPER 88-2354] p 23 A88-32294

OSMOSIS
Use of hydrophilic polymer coatings for control of electroosmosis and protein adsorption p 119 N88-15620

OUTGASSING
A simple model for the initial phase of a water plasma cloud about a large structure in space
[AIAA PAPER 88-0430] p 95 A88-22320
Outgassing of spacecraft composites p 95 A88-31404
Outgassing data for selecting spacecraft materials
[NASA-RP-1124] p 95 N88-10117

OXIDATION
Oxidation and protection of fiberglass-epoxy composite masts for photovoltaic arrays in the low Earth orbital environment
[NASA-TM-100839] p 97 N88-16734

OXIDATION RESISTANCE
Oxidation-resistant reflective surfaces for solar dynamic power generation in near earth orbit p 70 A88-18523

OXYGEN
High intensity 5 eV O atom exposure facility for material degradation studies p 96 N88-10847
Spacecraft surface exposure to atomic oxygen in low Earth orbit p 96 N88-11715
Fire-related medical science p 156 N88-12525
Ignition and combustion of metals in oxygen p 79 N88-12530

OXYGEN ATOMS
A measurement of the angular distribution of 5 eV atomic oxygen scattered off a solid surface in earth orbit p 130 A88-16866
Degradation mechanisms of materials for large space systems in low Earth orbit
[NASA-CR-181472] p 96 N88-10896
Mast material test program (MAMAT(F))
[NASA-TM-100821] p 31 N88-19592

OXYGEN PRODUCTION
Static feed electrolyzer technology advancement for space application
[SAE PAPER 871450] p 40 A88-21110
An experimental study of the Bosch and the Sabatier CO2 reduction processes
[SAE PAPER 871517] p 43 A88-21162
The feasibility of Chlorella as the exchanger of CO2 for O2 and the food resources in the Space Station p 43 A88-29136

OXYGEN SUPPLY EQUIPMENT
Performance evaluation of SPE electrolyzer for Space Station life support
[SAE PAPER 871451] p 40 A88-21111
High pressure water electrolysis for the Space Station
[SAE PAPER 871473] p 41 A88-21129

P

PACKETS (COMMUNICATION)
A packetized remote visual access data system for Space Station interactive payload operations p 99 A88-21253

PANELS
Solution of structural analysis problems on a parallel computer
[AIAA PAPER 88-2287] p 22 A88-32240

PARABOLIC ANTENNAS
Optimal reconfiguration of thermally distorted wire mesh reflectors for large space antennas
[AIAA PAPER 88-2340] p 23 A88-32283

PARABOLIC REFLECTORS
Wavefront error sensing
[NASA-CR-181504] p 76 N88-13030
The integration of a mesh reflector to a 15-foot box truss structure. Task 3: Box truss analysis and technology development
[NASA-CR-178226] p 31 N88-18941

PARALLEL COMPUTERS
Solution of structural analysis problems on a parallel computer
[AIAA PAPER 88-2287] p 22 A88-32240
Report from the MPP Working Group to the NASA Associate Administrator for Space Science and Applications
[NASA-TM-87819] p 100 N88-11402

PARALLEL PROCESSING (COMPUTERS)
The use of transputers in processing telemetry data p 98 A88-15303
Three parallel computation methods for structural vibration analysis
[AIAA PAPER 88-2391] p 24 A88-32323
The component-mode method in a parallel computer environment
[AIAA PAPER 88-2438] p 8 A88-32355
Computational methods for problems in aerodynamics and large space structure using parallel and vector architectures
[AD-A185401] p 27 N88-13294
ESA Bulletin No. 25
[ISSN-0376-4265] p 146 N88-16767

PARALLEL PROGRAMMING
Report from the MPP Working Group to the NASA Associate Administrator for Space Science and Applications
[NASA-TM-87819] p 100 N88-11402

PARAMETER IDENTIFICATION
Distributed systems approach to the identification of flexible structures p 15 A88-22808
A parameter robust LQG design synthesis with applications to control of flexible structures p 15 A88-27319
Some experiences with the Eigensystem Realization Algorithm p 17 A88-29815
Multiple boundary condition test (MBCT) - identification with mode shapes
[AIAA PAPER 88-2353] p 23 A88-32293
Torturing recursive parameter identification algorithms with a gap nonlinearity
[AIAA PAPER 88-2439] p 24 A88-32356
Survey of parameter estimation methods in experimental modal analysis p 24 A88-32718

PARTICLE BEAMS
Physics and chemistry p 119 N88-15359

PARTICLE COLLISIONS
Planetary science p 5 N88-15356

PARTICLE ENERGY
Plasmoid power station
[IAF PAPER 87-250] p 69 A88-15869

PARTICLE INTERACTIONS
Feasibility study for gas-grain simulation facility
[NASA-CR-177468] p 28 N88-13954

PARTICLES
Microgravity Particle Research on the Space Station
[NASA-CP-2496] p 119 N88-15354
Astrophysics and the solar nebula p 119 N88-15355
Planetary science p 5 N88-15356
Physics and chemistry p 119 N88-15359

PASSAGEWAYS
Personnel occupied woven envelope robot power
[NASA-CR-182367] p 99 N88-15196

PAYLOAD CONTROL
Pointing mount with active vibration isolation for large payloads
[AAS PAPER 87-033] p 100 A88-16893

PAYLOAD DELIVERY (STS)
Ram accelerator direct launch system for space cargo
[IAF PAPER 87-211] p 162 A88-15844
Small reentry vehicles p 150 A88-28364

PAYLOAD INTEGRATION
The potential of Columbus element utilisation
[IAF PAPER 87-04] p 137 A88-15865
A data base approach towards Columbus payload accomodation p 99 A88-21257
Columbus utilization preparation - Status of ongoing studies p 141 A88-21585
A monograph of the National Space Transportation System Office (NSTSO) integration activities conducted at the NASA Lyndon B. Johnson Space Center for the EASE/ACCESS payload flown on STS 61-B p 27 N88-10876
EASE/ACCESS ground processing at Kennedy Space Center p 27 N88-10877
RETE experiment Assembly, integration, and Verification (AIV) activities
[IFSI-87-6] p 117 N88-13380
An AI approach for scheduling space-station payloads at Kennedy Space Center p 90 N88-16425
Coorbiting Platform Utilization Study (CPLUS), executive summary — Columbus
[SN-WP-4000-DOC-8809/85-F] p 120 N88-16796

PAYLOAD RETRIEVAL (STS)
Cost-effective orbit transfer modes for satellite retrieval and servicing — Space Station p 61 N88-19493
Review of commercial spacecraft: Recovery and repair experiences. Implications for future spacecraft designs and operations p 128 N88-19528

197

PAYLOADS
Space Station accommodation of attached payloads
[IAF PAPER 87-97] p 163 A88-15868
AUTOPLAN - A PC-based automated mission planning tool p 7 A88-20486
Assessment of external contamination for Space Station scientific payloads
[SAE PAPER 871476] p 130 A88-21131
ENVIRONET database on vibroacoustics
[AIAA PAPER 88-0010A] p 99 A88-22011
Estimating payload internal temperatures and radiator size for multimegawatt space platforms
[DE88-000244] p 37 N88-11728
The effect of maximum-allowable payload temperature on the mass of a multimegawatt space-based platform
[DE88-001921] p 37 N88-13381
Carbon Dioxide observational platform system (CO-OPS) Feasibility Study
[NASA-CR-179225] p 118 N88-14113
Performance considerations for the astrometric telescope facility on the phase 1 space station
[NASA-TM-100040] p 45 N88-14836
Coorbiting Platform Utilization Study (CPLUS), executive summary --- Columbus
[SN-WP-4000-DOC-8809/85/F] p 120 N88-16798
A lunar transportation system
[NASA-CR-182581] p 107 N88-19379
Preliminary analysis of an integrated logistics system for OSSA payloads
[NASA-CR-4114] p 6 N88-19477
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 1: Executive summary p 6 N88-19478
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 2: OSSA integrated logistics support strategy p 6 N88-19479
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 3: OSSA integrated logistics support planning document p 6 N88-19480
Automatic in-orbit payload deployment mechanisms, logistic operations and transport vehicle design compatibilities p 92 N88-19493
PENETRATION
Space station integrated wall design and penetration damage control
[NASA-CR-179169] p 25 N88-10070
Space station integrated wall damage and penetration damage control. Task 5: Space debris measurement, mapping and characterization system
[NASA-CR-179281] p 50 N88-17688
PERFORATED PLATES
Analysis of oblique hypervelocity impact phenomena
[AIAA PAPER 88-2370] p 23 A88-32307
PERFORMANCE PREDICTION
Advanced photovoltaic solar array design
p 63 A88-11793
REPPRE,REPSIM,REPSTA - Programs for evaluating the availability and maintenance of space systems
p 125 A88-27779
Orbit lifetime characteristics for Space Station
[AIAA PAPER 88-2490] p 55 A88-31388
OMV man/system simulation integration: A preliminary analysis and recommendation
[NASA-CR-182602] p 151 N88-20005
PERFORMANCE TESTS
Integrated heat pipe-thermal storage system performance evaluation p 32 A88-11803
Design, analysis, fabrication and test of the LAMAR prototype mirror assembly --- Large Area Modular Array of Reflectors p 10 A88-12719
Initial results of integrated testing of a regenerative ECLSS at MSFC
[SAE PAPER 871454] p 41 A88-21114
High thermal-transport capacity heat pipes for space radiators
[SAE PAPER 871520] p 35 A88-21155
NASA to evaluate two suit designs for Space Station
p 155 A88-24101
Design and verification of the FLECS test structure --- Flexible ECS-type structure p 54 A88-27779
Structural model verification with LQG theory --- Linear Quadratic Optimization
[AIAA PAPER 88-2360] p 23 A88-32300
Space station propulsion technology: Space station propulsion system test bed test plan
[NASA-CR-179201] p 78 N88-10104
Rendezvous and Docking Verification (RVDV) and in-orbit demonstration, executive summary
[RVD-RVDV-FR-AS-01] p 127 N88-14120
Simulation test beds for the space station electrical power system
[NASA-TM-100786] p 74 N88-17715
Columbus feasibility studies. Volume 4: Integration, test, and operations
[ETN-88-90576] p 147 N88-18814
Simulation and tests of a satellite attitude and orbit control system: General considerations concerning an example case (INPE) and design of a servo rate table
[INPE-4282-PRE/1154] p 62 N88-19572
PERIPHERAL CIRCULATION
Cardiac and peripheral circulation assessment by ultrasound on 3 astronauts during two 7-day space flights (1982 Salyut-7 - 1985 STS-51G) p 158 N88-19921
PERSONAL COMPUTERS
AUTOPLAN - A PC-based automated mission planning tool p 7 A88-20486
PERTURBATION
Large-angle slewing maneuvers for flexible spacecraft
[NASA-CR-4123] p 60 N88-16080
PERTURBATION THEORY
Application of perturbation techniques to flexible multibody system dynamics p 14 A88-20908
Maneuvering and vibration control of flexible spacecraft p 52 A88-22932
A recursive pole placement method for large flexible structures p 19 A88-31567
Design of low order controllers for robust disturbance rejection on large space structures
[AD-A185202] p 50 N88-13376
PHASE CHANGE MATERIALS
Solar receiver for the Space Station Brayton engine
[ASME PAPER 87-GT-252] p 62 A88-11134
PHASE LOCKED SYSTEMS
An amplitude modulated laser system for distance and displacement measurement p 47 A88-12813
PHASE SHIFT KEYING
High data rate modem simulation for the space station multiple-access communications system
p 101 N88-14670
PHASE TRANSFORMATIONS
Atmospheric science p 5 N88-15357
PHASED ARRAYS
The X-ray large array II - Implementation
[AIAA PAPER 88-0804] p 14 A88-23466
PHOTOELECTRIC CELLS
Optimization of the parameters of a solar photoelectric system exposed to cosmic rays p 72 A88-28250
PHOTOELECTRONS
The effect of photoelectrons on boom-satellite potential differences during electron beam ejection
[AD-A190390] p 75 A88-20390
PHOTOVOLTAIC CELLS
A novel photovoltaic power system which uses a large area concentrator mirror p 65 A88-11811
Performance characteristics of a combination solar photovoltaic heat engine energy converter
p 65 A88-11813
Optical measurements pertaining to Space Station solar dynamic power systems
[IAF PAPER 87-029] p 69 A88-15954
Photovoltaic power modules for NASA's manned space station
[NASA-TM-100229] p 72 N88-11745
Low Earth orbit environmental effects on the space station photovoltaic power generation systems
[NASA-TM-100230] p 73 N88-12429
Oxidation and protection of fiberglass-epoxy composite masts for photovoltaic arrays in the low Earth orbital environment
[NASA-TM-100839] p 97 N88-19734
Mast material test program (MAMATEP)
[NASA-TM-100821] p 31 N88-19592
PHOTOVOLTAIC CONVERSION
Advanced photovoltaic solar array design
p 63 A88-11750
Solar concentrator advanced development project
p 64 A88-11799
Reliability models for Space Station power system
p 66 A88-11815
Photovoltaics for commercial solar power applications: Proceedings of the Meeting, Cambridge, MA, Sept. 16, 19, 1986
[SPIE-706] p 70 A88-21601
Space solar cell research - Problems and potential
p 70 A88-21605
PHOTOVOLTAIC EFFECT
Development of an advanced photovoltaic concentrator system for space applications p 65 A88-11812
PHYSICAL EXERCISE
An innovative exercise method to simulate orbital EVA work - Applications to PLSS automatic controls
[SAE PAPER 871475] p 154 A88-21130
PHYSIOCHEMISTRY
Controlled Ecological Life Support Systems (CELSS) physiochemical waste management systems evaluation
[NASA-CR-177402] p 45 N88-14626
PHYSIOLOGICAL EFFECTS
Providing artificial gravity - Physiologic limitations to rotating habitats
[IAF PAPER 87-545] p 152 A88-16163
Medical effects of iodine disinfection products in spacecraft water
[SAE PAPER 871490] p 154 A88-21144
Scientific objectives and functional requirements of life sciences in the Space Station p 159 N88-16264
Basic results of medical studies during prolonged manned flights on board the Salyut-7/Soyuz-T orbital complex
[NASA-TT-20217] p 147 N88-19162
Implications of shuttle/s in space for human physiology experiments p 129 NO3-19942
PIEZOELECTRIC TRANSDUCERS
Active control of flexural vibrations in beams
p 59 N88-14868
PINHOLE OCCULTER FACILITY
Pinhole occulter experiment
[NASA-CR-179206] p 116 N88-11401
PIPES (TUBES)
Protective coatings for composite tubes in space applications p 14 A88-13239
EVA construction and repair of tubular systems on Space Station
[AIAA PAPER 88-2456] p 125 A88-31381
Development and properties of aluminum-clad graphite/epoxy tubes for space structures
[AIAA PAPER 88-2472] p 18 A88-31389
PLANAR STRUCTURES
Dynamics and control of a planar truss actuator
p 55 A88-31564
PLANETARY ATMOSPHERES
Planetary science p 5 N88-15356
Atmospheric science p 5 N88-15357
PLANETARY MANTLES
Astrophysics and the solar nebula
p 119 N88-15355
PLANNING
Prototype resupply scheduler p 9 N88-16426
Preliminary analysis of an integrated logistics system for OSSA payloads
[NASA-CR-4114] p 6 N88-19477
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 3: OSSA integrated logistics support planning document p 6 N88-19480
PLANTS (BOTANY)
Solar plant growth facility (SPGF) - An approach toward future biological life support systems
p 155 A88-29141
Space station accommodations for life sciences research facilities. Phase 1: Conceptual design and programmatics studies for Missions SAAX0307, SAAX0302 and the transition from SAAX0307 to SAAX0302. Volume 2: Study results
[NASA-CR-179244] p 104 N88-15829
Space station accommodations for life sciences research facilities. Phase A: conceptual design and programmatics studies for Missions SAAX0307, SAAX0302 and the transition from SAAX0307 to SAAX0302. Volume 1: Executive summary
[NASA-CR-179267] p 104 N88-19571
PLASMA CLOUDS
Plasma contactors for use with electrodynamic tethers for power generation
[IAF PAPER 87-051] p 69 A88-15970
A simple model for the initial phase of a water plasma cloud about a large structure in space
[AIAA PAPER 88-0430] p 95 A88-22330
PLASMA ENGINES
Study of Plasma Motor Generator (PMG) tether system for orbit reboost
[NASA-CR-172016] p 117 N88-12601
PLASMA GENERATORS
Plasma contactors for use with electrodynamic tethers for power generation
[NASA-CR-182404] p 73 N88-19547
PLASMA INTERACTIONS
Numerical analysis of interaction of a high-voltage solar array with ionospheric plasma p 72 A88-27886
Analysis of geophysical data bases and models for spacecraft interactions
[AD-A184809] p 100 N88-13375
PLASMA PHYSICS
A simple model for the initial phase of a water plasma cloud about a large structure in space
[AIAA PAPER 88-0430] p 95 A88-22330
Space Environment Technology --- conference
[ISBN-2-85428-170-5] p 132 N88-11702
PLASMA POWER SOURCES
Plasma contactors for use with electrodynamic tethers for power generation
[IAF PAPER 87-051] p 69 A88-15970
PLASMA PROPULSION
Study of Plasma Motor Generator (PMG) tether system for orbit reboost
[NASA-CR-172016] p 117 N88-12601

PLASMA WAVES
Alfven waves from an electrodynamic tethered satellite system p 115 A88-25890
PLASMA-ELECTROMAGNETIC INTERACTION
Environmental interactions of solar generators in space p 72 N88-11730
Laboratory simulation of the electrodynamic interactions of a tethered satellite with an ionospheric plasma [PPPL-86-5] p 119 N88-15822
PLASMA-PARTICLE INTERACTIONS
Planetary science p 5 N88-15356
PLATINUM
Compatability of dispersion-strengthened platinum with resistojet propellants [NASA-TP-2765] p 70 N88-12539
PNEUMATIC CONTROL
Space station resistojet system requirements and interface definition study [NASA-CR-180837] p 80 N86-12547
POINTING CONTROL SYSTEMS
Pointing mount with active vibration isolation for large payloads [AAS PAPER 87-033] p 103 A88-16993
Design of robust line-of-sight pointing control system for the SCOLE configuration p 54 A88-27367
Wavefront error sensing [NASA-CR-181504] p 70 N88-12030
Progress toward a cosmic dust collection facility on space station [NASA-CR-182427] p 121 N88-19588
POLAR ORBITS
Environmental constraints for Polar Platform design [IAF PAPER 87-09] p 104 A88-15809
The utilization of the Columbus Polar Platform [IAF PAPER 87-98] p 162 A88-15969
Operational utilization of the polar platforms [IAF PAPER 87-116] p 159 A88-15982
NASA spaceborne optical disk recorder development p 100 A88-24620
Study of mobile communications payload for Columbus Polar Platforms [ITS TN-0458A-86] p 75 N88-10330
Polar platform element of Space Station: Mission objectives, European priorities, candidate instrumentation and selection procedure p 119 N88-19779
POLARIZATION (CHARGE SEPARATION)
Atmospheric science p 5 N88-11357
POLICIES
Status of ongoing government-level negotiations on space stations p 132 A86-12444
New space priorities in the USSR p 139 A86-19626
Colloquium on the Law of Outer Space, 29th, Stockholm, Sweden, Oct. 7-12, 1985, Proceedings p 164 A86-26197
National Aeronautics and Space Administration space station proposal, fiscal year 1988 [S-HRG-100-329] p 166 N88-14043
POLITICS
Proceedings of the Fourth Annual L5 Space Development Conference p 163 A89-22000
POLLUTION CONTROL
Contamination control concepts for space station customer servicing p 131 N80-10860
POLYIMIDES
Space environmental effects on polymeric materials [NASA-CR-182454] p 97 N88-16879
POLYMER MATRIX COMPOSITES
Space environmental effects on polymeric materials [NASA-CR-182418] p 97 N88-15082
POLYMERIC FILMS
Use of hydrophilic polymer coatings for control of electroosmosis and protein adsorption p 119 N88-15620
POLYMERS
Polymer crystal growth facility concept for Space Station laboratory module p 1 A88-15314
Space environmental effects on polymeric materials [NASA-CR-182454] p 97 N88-16879
PORTABLE LIFE SUPPORT SYSTEMS
European EVA requirements and space suit design [IAF PAPER 87-41] p 152 A88-15830
EVA for a European Scenario [SAE PAPER 871432] p 123 A88-21095
An innovative exercise method to simulate orbital EVA work - Applications to PLSS automatic controls [SAE PAPER 871475] p 154 A88-21130
POTABLE WATER
Review of water disinfection techniques [SAE PAPER 871488] p 42 A88-21142
Consequences of bacterial resistance to disinfection by iodine in potable water [SAE PAPER 871489] p 42 A88-21143
Treatment bed microbiological control [SAE PAPER 871490] p 42 A88-21146
POWER CONDITIONING
IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volumes 1, 2, 3, & 4 p 63 A88-11776
Solar concentrator advanced development project p 64 A88-11799
Control considerations for high frequency, resonant, power processing equipment used in large systems p 47 A88-11829
Application of advanced automation techniques in the Space Station electrical power system p 75 A88-11855
Power and resource management scheduling for scientific space platform applications p 108 A88-11880
Cooperating expert systems for power systems - Space Station resource allocation p 68 A88-11881
Expert system for fault detection and recovery for a space based power management and distribution system p 68 A88-11882
Cooperating expert systems for Space Station power distribution management p 71 A88-21630
The distributed AI system for the dynamic allocation and management of power (DAISY-DAMP) testbed p 84 A88-21638
Estimating payload internal temperatures and radiator size for multimegawatt space platforms [DE88-000244] p 57 N88-11736
POWER CONVERTERS
Design techniques for 20K Hz power converters p 66 A88-11822
POWER EFFICIENCY
Electrical power system for low earth orbit spacecraft applications p 45 A88-11817
POWER FACTOR CONTROLLERS
An integrated approach to space station power system autonomous control p 67 A88-11853
Use of a distributed microprocessor network for control of the Space Station electrical power system p 67 A88-11856
POWER MODULES (STS)
Photovoltaic power modules for NASA's manned space station [NASA-TM-100229] p 72 N88-11745
POWER TRANSMISSION
Preliminary conceptual design and weight of a one-megawatt space-based laser power station utilizing a solar-pumped iodine lasant p 65 A88-11816
Proposal of adaptively controlled transmitting array for microwave power transmission in space p 53 A86-25954
POWER TRANSMISSION (LASERS)
Laser solar power satellites - A case study in technology forecasting p 68 A88-15402
PRECIPITATION HARDENING
Compatability of dispersion-strengthened platinum with resistojet propellants [NASA-TP-2765] p 70 N88-12539
PREDICTION ANALYSIS TECHNIQUES
Predictive momentum management for a space station measurement and computation requirements [NASA-CR-172026] p 58 N88-10866
The dynamics and control of large flexible space structures, part 10 [NASA-CR-182429] p 29 N88-15830
PRESSURE CHAMBERS
Columbus pressurized module verification p 145 N88-10842
PRESSURE DEPENDENCE
Ignition and combustion of metals in oxygen p 79 N88-12530
PRESSURE VESSELS
Stress rupture behavior of carbon-fiber metal-lined pressure vessels for 30-year operation in space [AIAA PAPER 88-2479] p 19 A88-31391
PRESSURIZED CABINS
Columbus ECLSS [SAE PAPER 871430] p 139 A88-21090
Thermal control definition of Columbus pressurized modules [SAE PAPER 871483] p 139 A88-21139
Space Station pressure wall repair techniques [AIAA PAPER 88-2498] p 19 A88-31397
PRESSURIZING
Columbus pressurized modules - A challenging opportunity for microgravity research and application [IAF PAPER 87-575] p 137 A88-16050
The Columbus Attached Pressurized Module - System and management aspects of international cooperation p 139 A88-21252
PRIMITIVE EARTH ATMOSPHERE
Exobiology and life science p 118 N88-15358
PRIORITIES
New space priorities in the USSR p 139 A86-19626
PROBLEM SOLVING
Large space structures testing [AAS PAPER 87-036] p 13 A88-16906
Processes in construction of failure management expert systems from device design information p 96 A88-24230
PRODUCT DEVELOPMENT
Robotic sensors and actuators for a service manipulator system. Volume 3, phase A report and program plan [MATRA-EPT/DT/vT187/SR] p 87 N88-10343
Commercial perspective of an imaging spectrometer development program p 165 N88-12138
Microgravity and Materials Processing Facility study (MMPF): Requirements and Analyses of Commercial Operations (RACO) preliminary data release [NASA-CR-179309] p 104 N88-18742
EVA, the technological challenge p 129 N88-19535
PRODUCTIVITY
Technology advancements to improve crew productivity in space p 151 A88-15393
Crew productivity issues in long-duration space flight [AIAA PAPER 88-0444] p 154 A88-22330
PROGRAM VERIFICATION (COMPUTERS)
Space station software reliability analyses based on failures observed during testing at the multisystem integration facility p 101 N88-14884
PROJECT MANAGEMENT
Space Station careens past all obstacles p 109 A88-10367
Long range planning at NASA [IAF PAPER 87-670] p 163 A88-16243
Columbus feasibility studies. Volume 5: Programmatics [ETN-88-91076] p 147 N88-10802
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 2: Study results. Appendix E: Work breakdown structure and dictionary [NASA-CR-179274] p 48 N88-17723
Project management in astronautics: From Spacelab to Columbus [MBB-UR-943-87] p 167 N88-17938
PROJECT PLANNING
Project Horizon - An early study of a lunar outpost [IAF PAPER 87-659] p 105 A88-16237
Life sciences biomedical research planning for Space Station [SAE PAPER 871464] p 153 A88-21122
Automatic planning research applied to orbital construction p 124 A88-21637
Planning framework for high-technology space flight (OHR) p 142 A88-23516
Knowledge-based simulation p 102 N88-18404
Planning and scheduling for robotic assembly p 90 N88-18418
Planning activities in space p 9 N88-18417
An AI approach for scheduling space-station payloads at Kennedy Space Center p 90 N88-18425
Critical issues in NASA information systems [NASA-CR-182380] p 102 N88-18577
Columbus feasibility studies. Volume 5: Programmatics [ETN-88-91076] p 147 N88-10802
The 1987 Get Away Special Experimenter's Symposium [NASA-CP-2500] p 121 N88-17691
The NORSTAR Program: Space shuttle to space station p 167 N88-17718
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 2: Study results. Appendix E: Work breakdown structure and dictionary [NASA-CR-179274] p 48 N88-17723
PROPELLANT STORAGE
Orbital Spacecraft Consumables Resupply System (OSCRS). Volume 2: Study results [NASA-CR-172011] p 126 N88-11687
PROPELLANT TANKS
Orbital Spacecraft Consumables Resupply System p 122 A88-15252
Orbital transfer vehicle studies overview p 150 N88-15831
PROPELLANT TRANSFER
Orbital Spacecraft Consumables Resupply System (OSCRS). Volume 1: Executive summary [NASA-CR-172010] p 126 N88-13368
Servicer system demonstration plan and capability development [NASA-CR-179249] p 127 N88-15880
PROPELLANTS
Water-propellant resistojets for man-tended platforms [IAF PAPER 87-250] p 78 A88-15975
SAMSS: An in-progress review of the Spacecraft Assembly, Maintenance, and Servicing Study p 127 N88-15830

199

PROPORTIONAL LIMIT
Carbon fiber reinforced glass matrix composites for space based applications
[AD-A184355] p 96 N88-12546
PROPRIOCEPTION
Covariant control of bilateral servos for on-orbit manipulation p 62 N88-19520
PROPULSION
Experience of the Salyut-7 propulsion system (PS) repair operations
[AIF PAPER 87-67] p 127 A88-15861
PROPULSION SYSTEM CONFIGURATIONS
Concept studies for a laser powered Orbital Transfer vehicle
[AIF PAPER 87-200] p 77 A88-15807
Space Station propulsion system technology p 78 A88-21255
Space station onboard propulsion system Technology study
[NASA-CR-179233] p 50 N88-15006
PROPULSION SYSTEM PERFORMANCE
Optimization of the energy systems of manned orbital stations - Mathematical modeling and selection of efficient structures — Russian book p 68 A88-15864
Space station propulsion
[NASA-TM-100218] p 79 N88-11746
PROTECTIVE COATINGS
Protective coatings for composite tubes in space applications p 94 A88-13239
Oxidation-resistant reflective surfaces for solar dynamic power generation in near earth orbit p 70 A88-19523
Chromic acid anodizing of aluminum foil
[NASA-CR-179417] p 97 N88-19077
Use of hydrophilic polymer coatings for control of electroosmosis and protein adsorption p 119 N88-19620
Oxidation and protection of fiberglass-epoxy composite masts for photovoltaic arrays in the low Earth orbital environment
[NASA-TM-100839] p 97 N88-19734
Mast material test program (MAMATEP)
[NASA-TM-100821] p 51 N88-19192
PROTEINS
The protein crystallization facility (PCF) for Eureca
[AIF PAPER 87-412] p 110 A88-16082
Advanced protein crystal growth flight hardware for the Space Station
[AIAA PAPER 88-0345] p 9 A88-22253
Use of hydrophilic polymer coatings for control of electroosmosis and protein adsorption p 119 N88-19620
PROTOPLANETS
Astrophysics and the solar nebula p 118 N88-15355
Exobiology and life science p 118 N88-15356
PROTOTYPES
Cooperating expert systems for power systems — Space Station resource allocation p 68 A88-11981
Design of an ammonia two-phase Prototype Thermal Bus for Space Station
[SAE PAPER 871536] p 35 A88-21152
Prototype space station automation system delivered and demonstrated at NASA p 45 N88-10442
PROVING
Comments on the early experimental validation session of the Second International Conference on Tethers in Space
[AIAA PAPER 88-0535] p 113 A88-22409
Columbus pressurized module verification p 145 N88-10942
KBS V and V as related to automation of space station subsystems. Rationale for a KBS lifecycle p 9 N88-16075
Simulation test beds for the space station electrical power system
[NASA-TM-100798] p 74 N88-17715
Robotics servicing experiment — European space programs p 93 N88-19529
Rendezvous and docking (RVD) verification and demonstration on-orbit p 62 N88-19531
PROVISIONING
Inventory behavior at remote sites p 5 N88-14873
PSEUDOMONAS
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment p 146 N88-12917
PSYCHIATRY
Psychiatric components of a Health Maintenance Facility (HMF) on Space Station p 153 A88-25804
PULSED LASERS
An amplitude modulated laser system for distance and displacement measurement p 47 A88-12813
PULTRUSION
Potential for on-orbit manufacture of large space structures using the pultrusion process
[NASA-TM-4019] p 28 N88-13386

Q

QUALITY CONTROL
EMC and power quality standards for 20-kHz power distribution p 66 A88-11630

R

RADARSAT
A near field test system for very large antennas p 13 A88-17599
RADIATION BELTS
Analysis of geophysical data bases and models for spacecraft interactions
[AD-A184809] p 100 N88-13073
RADIATION CHEMISTRY
Astromag: A particle spectrometer for the Space Station
[PREPRINT 557] p 119 N88-14338
RADIATION DAMAGE
Space environmental considerations for a long-term cryogenic storage vessel p 80 N88-15023
RADIATION DOSAGE
Radiation problems with the Space Station scenario and the necessary surveillance for astronauts
[AIF PAPER 87-542] p 174 A88-16160
Radiation hazards on space missions p 145 A88-22919
RADIATION EFFECTS
Large space systems environmental interactions
[AIAA PAPER 88-0368] p 14 A88-22286
The combined release and radiation effects satellite: a joint NASA/DOD program p 131 N88-10851
Degradation mechanisms of materials for large space systems in low Earth orbit
[NASA-CR-181472] p 96 N88-10896
Low Earth orbit environmental effects on the space station photovoltaic power generation systems
[NASA-TM-100293] p 73 N88-12429
Radiation problems in manned space flight with a view to the Space Station p 132 N88-19934
Antibiotic activity in space: results and hypothesis p 109 N88-19952
RADIATION HAZARDS
Radiation hazards on space missions p 130 A88-22919
RADIATION SHIELDING
Radiation problems in manned space flight with a view to the Space Station p 132 N88-19934
RADIATIVE HEAT TRANSFER
Self-shadowing effects on the thermal-structural response of orbiting trusses p 32 A88-11734
Thermal design of the equipment platforms
[AIF PAPER 87-06] p 34 A88-10408
Hybrid honeycomb panel heat rejection system
[SAE PAPER 871419] p 34 A88-21080
RADIO ALTIMETERS
Swath altimetry of oceans and terrain p 115 A88-27939
RADIO FREQUENCIES
A composite structural system for a large collapsible space antenna p 19 A88-31403
RADIO SOURCES (ASTRONOMY)
L-SGR report: Space
[JPRS-USP-87-009] p 144 N88-10050
RADIOBIOLOGY
Radiation problems with the Space Station scenario and the necessary surveillance for astronauts
[AIF PAPER 87-542] p 129 A88-16160
RADIOGRAPHY
Method of radiographic inspection of wooden members
[NASA-CASE-LAR-13724-1] p 149 N88-23980
RAMAN SPECTRA
Raman spectra of adsorbed layers on space shuttle and AOTV thermal protection system surface p 132 N88-14880
RAMAN SPECTROSCOPY
Raman spectra of adsorbed layers on space shuttle and AOTV thermal protection system surface p 132 N88-14880
RAMJET ENGINES
Ram accelerator direct launch system for space cargo
[AIF PAPER 87-211] p 162 A88-15844
RANDOM VIBRATION
ENVIRONET database on vibroacoustics
[AIAA PAPER 88-0015A] p 99 A88-23611
RANKINE CYCLE
Toluene stability Space Station Rankine power system p 63 A88-11794
Binary mercury/organic Rankine cycle power systems p 63 A88-11795
Solar dynamic organic Rankine cycle heat rejection system simulation p 65 A88-11808
Solar thermodynamic power systems in space p 72 A88-20150
RAREFIED GAS DYNAMICS
Tethered space system - A new facility for experimental rarefied gas dynamics p 111 A88-16858
Low density orbithermodynamics studies performed by means of the tethered satellite system p 111 A88-16859
Tether satellite potential for rarefied gas aerodynamic research
[AIAA PAPER 88-0647] p 114 A88-22510
RAYLEIGH-RITZ METHOD
Some thoughts on the convergence of the classical Rayleigh-Ritz method and the finite element method
[AIAA PAPER 88-2269] p 31 A88-32025
REAL TIME OPERATION
Controlling real-time processes on the Space Station with expert systems p 64 A88-21634
OSSA's Telescience concept for the Space Station era
[AIAA PAPER 88-0125] p 112 A88-22583
Rapid toxicity detection in water quality control utilizing automated multispecies biomonitoring for permanent space stations p 94 N88-10848
Dynamics formulations for the real-time simulation of constrained motion p 60 N88-14872
TDAS: The Thermal Expert System (TEXSYS) data acquisition system p 102 N88-17758
RECORDERS
NASA spaceborne optical data recorder development p 100 A88-29620
RECOVERABILITY
Communications satellite systems operations with the space station. Volume 3: Supplementary technical report
[NASA-CR-180875] p 77 N88-16794
RECOVERABLE LAUNCH VEHICLES
A two stage launch vehicle for use as an advanced space transportation system to logistics support of the space station
[NASA-CR-182572] p 107 N88-19808
RECOVERABLE SPACECRAFT
The Eureca space platform p 143 A88-29858
RECTANGULAR PANELS
Advanced radiator concepts utilizing honeycomb panel heat pipes
[NASA-CR-172917] p 37 N88-12747
RECTENNAS
Space based nuclear microwave electric propulsion p 76 A88-22708
RECURSIVE FUNCTIONS
Torturing recursive parameter identification algorithms with a gap nonlinearity
[AIAA PAPER 88-2439] p 24 A88-32358
RECYCLING
Technology demonstrator program for Space Station Environmental Control Life Support System
[SAE PAPER 871458] p 41 A88-21115
Treatment bed microbiological control
[SAE PAPER 871492] p 42 A88-21146
An overview of Japanese CELSS research activities p 44 N88-12087
REDUCED GRAVITY
Research opportunities in microgravity science and applications during Shuttle hiatus p 108 A88-13164
Microgravity research and user support in the Space Station era - The Microgravity User Support Center
[AIF PAPER 87-380] p 110 A88-16081
Artificial gravity - A countermeasure for zero gravity
[AIF PAPER 87-533] p 155 A88-16158
Steady state micro-g environment on Space Station
[AIAA PAPER 88-0462] p 4 A88-31395
Active vibration control in microgravity environment p 55 A88-31580
Preliminary study of a containerless processing facility for Columbus, executive summary
[ESA-ITT-AO/1-1.834/85/F] p 96 N88-10855
Preliminary study of a gravitational biology facility for Columbus, executive summary
[MATRA-EPT/AS/VT209/255/NT] p 145 N88-10856
Research and development at the Marshall Space Flight Center Neutral Buoyancy Simulator p 5 N88-10878
A preliminary study of a fluid science laboratory for space station (Columbus). Part 4: Executive summary
[VALR-TR-87023-LPT-4] p 79 N88-11072
Microgravity combustion fundamentals p 79 N88-12528
Feasibility study for gas-grain simulation facility
[NASA-CR-177468] p 28 N88-13914
Allowable gravity-levels for Spacelab, Columbus and EURECA — materials science
[BF-R-88.109-P] p 152 N88-15784
Microgravity Particle Research on the Space Station
[NASA-CP-2496] p 118 N88-15354
Astrophysics and the solar nebula p 118 N88-15355
Planetary science p 5 N88-15358

200

Atmospheric science p 5 N89-15057
Exobiology and life science p 113 N89-15398
Physics and chemistry p 119 N89-15059
Tether Elevator Crawler Systems (TECS)
p 119 N89-15631
Cryogenic Fluid Management Technology Workshop. Volume 1: Presentation material and discussion
[NASA-CP-10001] p 80 N89-10924
Scientific objectives and functional requirements of life sciences in the Space Station p 158 N89-16264
Microgravity and Materials Processing Facility study (MMPF): Requirements and Analyses of Commercial Operations (FACO) preliminary data release
[NASA-CR-179309] p 104 N89-10742
Study of industry requirements that can be fulfilled by combustion experimentation aboard space station
[NASA-CR-180854] p 167 N89-10077
Life sciences in the framework of the ESA microgravity program and future flight opportunities
p 148 N89-10895
Cardiovascular adaptation to zero-g during a long term flight (237 days) on board the Salyut 7 Soviet manned station (1984) p 158 N89-10923
Cardiac and peripheral circulation assessment by ultrasound on 3 astronauts during two 7-day space flights (1982 Salyut-7 - 1985 STS 51G) p 158 N89-10401
Microgravity User Support Center (MUSC) for EURECA, Spacelab and Columbus missions p 140 N89-10947
Animal research on the Space Station
p 159 N89-10984

REDUCTION (CHEMISTRY)
An experimental study of the Bosch and the Sabatier CO2 reduction processes
[SAE PAPER 871017] p 43 A89-21162

REENTRY GUIDANCE
Aeroassisted orbital transfer vehicle guidance performance in the presence of density dispersions
[AIAA PAPER 88-0302] p 150 A89-22017

REENTRY VEHICLES
Interim Flight Opportunity (IFO) -- small European space experiment platform
[IAF PAPER 87-379] p 139 A88-16054
Small reentry vehicles p 150 A88-26364
Aerothermodynamics - A key to new aerospace transport systems
[DGLR PAPER 87-077] p 4 A88-32477

REFLECTOR ANTENNAS
Large inflatable space-rigidized antenna reflectors - Land mobile services development
[IAF PAPER 87-315] p 12 A88-16013
Radiation characteristics of offset radial rib reflector antennas p 34 A88-17585
Deployable umbrella reflector antennas -- Russian book p 143 A88-27743
Optimal reconfiguration of thermally distorted wire mesh reflectors for large space antennas
[AIAA PAPER 88-2340] p 22 A88-32283
Compensation of reflector antenna surface distortion using an array feed
[NASA-TM-100366] p 77 N88-19805

REFLECTORS
Oxidation-resistant reflective surfaces for solar dynamic power generation in near earth orbit p 70 A88-18523
Large deployable reflector thermal characteristics in low earth orbits
[AIAA PAPER 88-0471] p 36 A88-22347
Workshop on Technology Development Issues for the Large Deployable Reflector (LDR)
[NASA-CP-2407] p 32 N88-21235

REFRACTORY MATERIALS
Astrophysics and the solar nebula
p 113 N89-15355

REFRIGERATING
Large capacity cryopropellant orbital storage facility
p 80 N89-11932

REFUELING
High-energy orbit refueling for orbital transfer vehicles
p 150 A88-27997
Orbital Spacecraft Consumables Resupply System (OSCRS). Volume 4: Extended study results
[NASA-CR-172012] p 125 N89-11986
Orbital Spacecraft Consumables Resupply System (OSCRS): Monopropellant application to space station and OTV: automatic refueling impacts of an ELV launch, volume 4
[NASA-CR-172029] p 126 N89-11741
Orbital Spacecraft Consumables Resupply System (OSCRS). Volume 1: Executive summary
[NASA-CR-172010] p 126 N89-13366
SAMSS: An in-progress review of the Spacecraft Assembly, Maintenance, and Servicing Study
p 127 N89-13930

REGENERATION (ENGINEERING)
Initial results of integrated testing of a regenerative ECLSS at MSFC
[SAE PAPER 871454] p 61 A88-21114
Electrochemically regenerable carbon dioxide/moisture control technology for an Advanced Extravehicular Mobility Unit
[SAE PAPER 871410] p 41 A88-21126

REGENERATIVE FUEL CELLS
Monolithic fuel cell based power source for burst power generation p 71 A88-23501

REINFORCED PLASTICS
Recent advances in dynamics of composite structures
p 10 A88-31427

RELAY SATELLITES
Evaluation of control concepts for a large geostationary data relay satellite p 50 A88-16261

RELIABILITY ANALYSIS
Reliability models for Space Station power system
p 65 A88-11815
Incipient fault detection and power system protection for spaceborne systems p 66 A88-11826
Long-life assurance for Space Station - Is it an issue?
[A-04-PAPER-88-2489] p 73 A88-31398
Space station software reliability analysis based on failures observed during testing at the multisystem integration facility p 121 N89-14884

REMOTE CONTROL
Stability analysis for alternative force control schemes as applied to remote space teleoperation
[AAS PAPER 87-043] p 51 A88-16508
Telescience testbedding for life science missions on the Space Station
[AIAA PAPER 88-0496] p 16 A88-22102
Robotic sensors and actuators for a service manipulator system. Volume 1: Executive summary
[MATRA-EPT-/DT-/VT187-/120] p 97 N88-10341
Robotic sensors and actuators for a service manipulator system. Volume 2: Service Manipulator System (SMS) handbook
[MATRA-EPT-/DT-/VT187-/2...] p 97 N88-10342
Robotic sensors and actuators for a service manipulator system. Volume 3: phase A report and program plan
[MATRA-EPT-/DT-/VT187-/...] ... N88-10343
Teleoperation and control ... Orbital servicing
[SAE TP-8298] p 97 N88-10460
Promising concepts for ground-to-orbit ... manipulator teleoperation -- Columbus p 93 N88-19750
Utilization of robotics and teleoperation for future in-orbit operations p 93 N88-19527

REMOTE HANDLING
Dynamics, control and sensory issues pertinent to robotic hands for the EVA retriever system p 66 N89-14876

REMOTE MANIPULATOR SYSTEM
Control of in-orbit space manipulators
p 51 A88-16312
Control aspects of a European space manipulator system p 63 A88-16313
An orbiting control station for free flying teleoperators - Preliminary design methodology p 51 A88-21647
A relatively general formulation for studying dynamics of the Space Station based MRMS with duplications -- Mobile Remote Manipulator System
[AIAA PAPER 88-0674] p 52 A88-22504
An initial study of remotely manipulated stud welding for space applications p 66 A88-31274
Robotic sensors and actuators for a service manipulator system. Volume 1: Executive summary
[MATRA-EPT-/DT-/VT187-/120] p 97 N88-10341
Robotic sensors and actuators for a service manipulator system. Volume 2: Service Manipulator System (SMS) handbook
[MATRA-EPT-/DT-/VT187-/227] p 97 N88-10342
Teleoperation and control study -- orbital servicing
[SAE TP-8298] p 97 N88-10460
Telerobotic controller development p 80 N88-16370
Utilization of SMS and EVA for the servicing of European Space Station p 147 N88-19500
Robotic intelligence issues for space manipulator monitoring, control programming p 92 N88-19504
On a knowledge based assisted system for highly autonomous control of experiment manipulators in the Man-Tended Free Flyer p 92 N88-19505
Remote manipulation in orbital construction, servicing and repair missions: is one arm enough? A comparative evaluation of the performance features of robots with one or more arms p 93 N88-19509
Covariant control of bilateral servos for in-orbit manipulation p 62 N88-19530
A comparative survey of mathematical models for dynamic simulation of in-orbit manipulation operations p 148 N88-19533
A teleoperated manipulator system concept for unmanned platforms -- Columbus p 94 N88-19537

REMOTE SENSING
Deployment dynamics of accordion type of deployable solar arrays considering flexibility of closed control loops
[IAF PAPER 87-256] p 11 A88-15974
Remote sensing Earth's surface and atmosphere. Proceedings of Workshop II and the Topical Meeting of the 26th COSPAR Plenary Meeting, Toulouse, France, June 30-July 11, 1986 p 111 A88-17026
Earth observation from the Space Station
p 112 A88-23367
A packetized remote visual access data system for Space Station interactive payload operations
p 99 A89-21253
Earth observation and the Space Station
p 112 A89-21568
Applications of infrared satellites to some problems of terrestrial physics
[AIAA PAPER 89-0680] p 114 A89-27515
Observations of ocean and sea bottom relief from space p 140 A89-28399
Swath altimetry of oceans and terrain
p 115 A89-27838
Commercial Opportunities for Remote Sensing with Polar Platforms
[ESA-SP-289] p 117 N89-12131
Legal protection of the Polar Platform's users
p 140 N89-12135
Confidentiality of data -- Columbus Polar Platforms
p 140 N89-12138
X-band SAR for a European remote sensing payload
p 117 N89-12142
Technical aspects of future ocean colour remote sensing p 119 N89-16298
Tethers: An outline of a new concept for Earth observation p 120 N89-16761

REMOTE SENSORS
Operational utilization of the polar platforms
[IAF PAPER 87-116] p 109 A88-15852
Efficient placement of structural dynamics sensors on the space station
[NASA-CR-172015] p 25 N88-10103
Robotic sensors and actuators for a service manipulator system. Volume 1: Executive summary
[MATRA-EPT-/DT-/VT187-/120] p 97 N88-10341
Robotic sensors and actuators for a service manipulator system. Volume 2: Service Manipulator System (SMS) handbook
[MATRA-EPT-/DT-/VT187-/227] p 97 N88-10342
Robotic sensors and actuators for a service manipulator system. Volume 3, phase A report and program plan
[MATRA-EPT-/DT-/VT187-/229] p 97 N88-10343
Technical aspects of future ocean colour remote sensing p 119 N89-16298

RENDEZVOUS GUIDANCE
Space vehicle approach velocity judgments under simulated visual space conditions
[NASA-TM-89437] p 158 N89-19094

RENDEZVOUS TRAJECTORIES
Safe and fuel minimum reference trajectories for closed loop controlled approaches -- space stations
p 61 N89-19468

REQUIREMENTS
Space Station viewing requirements
[SAE PAPER 861754] p 1 A88-10155
Space Station Mission Planning System (MPS) development study. Volume 1: Executive summary
[NASA-CR-179202] p 4 N88-10047
Space Station Mission Planning System (MPS) development study. Volume 2
[NASA-CR-179200] p 4 N88-10048
Space Station Mission Planning Study (MPS) development study. Volume 3: Software development plan
[NASA-CR-179203] p 4 N88-10049
Telepresence work station system definition study, part 2
[NASA-CR-172006] p 4 N88-10071
Space Assembly, Maintenance, and Servicing Study (SAMSS) p 125 N88-10089
Structures and Materials Working Group report
p 25 N89-10093
Space station contamination considerations
p 131 N89-10859
Fire-related standards and testing
p 156 N89-12502
Design and assembly sequence analysis of option 3 for CETF reference space station
[NASA-TM-100103] p 106 N89-13369

RESCUE OPERATIONS
Crewman rescue equipment in manned space missions - Aspects of application
[IAF PAPER 87-576] p 153 A88-16187

RESEARCH AND DEVELOPMENT
NASA's Telerobotics R & D Program - Status and future directions
[IAF PAPER 87-24] p 92 A88-15816
An overview of the Office of Space Flight satellite servicing program plan
[IAF PAPER 87-55] p 102 A88-15825

201

Pathfinder technologies for lucid new missions — U.S. research and development program for space exploration
[IAF PAPER 87-46] p 1 A88-15832
Space Station Program implications from the viewpoint of the Space Station Operations Task Force
[IAF PAPER 87-62] p 123 A88-15856
Science on the Space Station: The opportunity and the challenge - A NASA view
[IAF PAPER 87-92] p 98 A88-15863
Trends to reduce development and operation costs for experiments of the future space laboratory
[IAF PAPER 87-100] p 105 A88-15871
Research and development of thin tension truss antenna
[IAF PAPER 87-317] p 12 A88-16015
Columbus pressurized modules - A challenging opportunity for microgravity research and application
[IAF PAPER 87-375] p 137 A88-16050
Human factor design of habitable space facilities
[IAF PAPER 87-549] p 28 A88-16166
Project Horizon - An early study of a lunar outpost
[IAF PAPER 87-659] p 105 A88-16237
Japan - Future space samurai? p 138 A88-16223
Environmental control and life support system requirements and technology needs for advanced manned space missions
[SAE PAPER 871433] p 39 A88-21096
Eureca - European user-friendly retrievable carrier
p 139 A88-21251
Explorer Platform — reusable spacecraft
[AIAA PAPER 88-0056] p 112 A88-22046
Space erectable radiator system development
[AIAA PAPER 88-0469] p 36 A88-22345
Spaceward ho — U.S. and Soviet space programs
[AIAA PAPER 88-0750] p 163 A88-22567
In-space research, technology and engineering experiments and Space Station p 3 A88-27750
Blagov commentary on Mir station, first manning
p 144 N88-10051
Space technology to meet future needs
[NASA-CR-181473] p 106 N88-10819
National Aeronautics and Space Administration Authorization Act, 1988
[PUB-LAW-100-147] p 167 N88-12422
Tethers in space handbook
[NASA-CR-181371] p 118 N88-14123
National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 1
[NASA-CR-172009-VOL-1] p 166 N88-14855
Research and technology, 1987
[NASA-TM-100323] p 167 N88-20253

RESEARCH FACILITIES
Research opportunities in microgravity science and applications during Shuttle hiatus p 108 A88-13164
Accommodating life sciences on the Space Station
[SAE PAPER 871412] p 39 A88-21077
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 1: Executive summary. Phase A: Conceptual design and programmatics
[NASA-CR-179268] p 104 N88-17721
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 2: Study results, attachment 2. Phase A: Conceptual design and programmatics
[NASA-CR-179272] p 46 N88-17722
Conceptual design and programmatics studies of space station accommodations for Life Sciences Research Facilities (LSRF)
[NASA-CR-179270] p 46 N88-19567
Space station accommodations for life sciences research facilities: Phase A conceptual design and programmatics studies for Missions SAAX0307, SAAX0302 and the transition from SAAX0307 to SAAX0302. Volume 1: Executive summary
[NASA-CR-179267] p 104 N88-19571

RESEARCH MANAGEMENT
Research opportunities in microgravity science and applications during Shuttle hiatus p 108 A88-13164
Report from the MPP Working Group to the NASA Associate Administrator for Space Science and Applications
[NASA-TM-87819] p 100 N88-11402
Study of industry requirements that can be fulfilled by combustion experimentation aboard space station
[NASA-CR-180854] p 167 N88-19377

RESISTOJET ENGINES
Water-propellant resistojets for man-tended platforms
[IAF PAPER 87-259] p 78 A88-15975
Space Station propulsion system technology
p 78 A88-21255
Space station propulsion
[NASA-TM-100216] p 79 N88-11746
Compatability of dispersion-strengthened platinum with resistojet propellants
[NASA-TP-2765] p 79 N88-12538
Space station resistojet system requirements and interface definition study
[NASA-CR-180832] p 80 N88-12541
Magnetic emissions testing of the space station engineering model resistojet
[NASA-TM-100788] p 81 N88-17726
Component data base for space station resistojet auxiliary propulsion
[NASA-CR-180834] p 81 N88-17731

RESONANCE
Control considerations for high frequency, resonant, power processing equipment used in large systems
p 47 A88-11829

RESONANT VIBRATION
Modal coupling of structures with complex storage moduli p 20 A88-31580

RESOURCE ALLOCATION
Power and resource management scheduling for scientific space platform applications
p 108 A88-11880
Planning activities on space p 9 N88-16417
An AI approach for scheduling space station payloads at Kennedy Space Center p 90 N88-16425
The resource envelope as a basis for space station management system scheduling p 102 N88-16427
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 2: OSSA integrated logistics support strategy p 5 N88-19479

RETRACTABLE EQUIPMENT
ERM: the deployable mast for Columbus — Extendable and Retractable Mast p 11 A88-15278
Development of the Extendable and Retractable Mast (ERM). Design phase 2. Volume 1 — spacecraft payloads
[RP-2010-0000-DS-09] p 31 N88-18750

REUSABLE SPACECRAFT
Development scenario of H-II Orbiting Plane, HOPE
[IAF PAPER 87-210] p 48 A88-15943
Costs and benefits of future heavy Space Freighters
[IAF PAPER 87-617] p 163 A88-16211
Explorer Platform — reusable spacecraft
[AIAA PAPER 88-0056] p 112 A88-22046
A conceptual design for a single-stage-to-orbit Space Station service vehicle
[AIAA PAPER 88-0099] p 3 A88-22063
The economics of satellite retrieval
[AIAA PAPER 88-0843] p 164 A88-27584
The Eureca space platform p 143 A88-28856
Reusable space systems (Eugen Saenger Lecture, 1987) p 125 A88-32476

RHEOLOGY
Physics and chemistry p 118 N88-15359

RIGID STRUCTURES
Motion perturbations of a dumbbell in a central Newtonian force field p 47 A88-11235
Minimum time attitude slewing maneuvers of a rigid spacecraft
[AIAA PAPER 88-0675] p 52 A88-22505
Dynamics and control of spacecraft with retargetting flexible antennas
[AIAA PAPER 88-2414] p 57 A88-32341
Formulation methods of rigid multibody systems for large space structures and some results of computer simulation
[NAL-TR-942] p 30 N88-17730

ROBOTICS
Control of gripper position of a compliant link using strain gauge measurements p 48 A88-14995
On the modeling and control of a flexible manipulator arm by point actuators p 92 A88-14996
Design and development of a computer-assisted ground control technique for Space Station robotics
p 62 A88-15264
Potentials of robotic operations on board the man-tended free-flyer
[IAF PAPER 87-17] p 82 A88-15813
NASA's Telerobotics R & D Program - Status and future directions
[IAF PAPER 87-24] p 82 A88-15816
The Flight Telerobotic Servicer (FTS) - A focus for automation and robotics on the Space Station
[IAF PAPER 87-25] p 82 A88-15817
Telerobotics and orbital laboratories - An end-to-end analysis and demonstration
[IAF PAPER 87-27] p 83 A88-15819
Automation and robotics technology application to JEM — Japanese Experiment Module
[IAF PAPER 87-74] p 136 A88-15849
Man tended free flyer interior equipment for manned and automated operation
[IAF PAPER 87-75] p 136 A88-15850
Control of in-orbit space manipulation
p 51 A88-16312
Experiments in advanced control concepts for space robotics - An overview of the Stanford Aerospace Robotics Laboratory
[AAS PAPER 87-044] p 83 A88-16999
Space telerobotics technology demonstration program
[AAS PAPER 87-045] p 84 A88-17000
Robots - Autonomous space workers
p 84 A88-19866
Use of automation and robotics for the Space Station
p 84 A88-21832
Intelligent systems and robotics for an evolutionary Space Station p 86 A88-24239
Development of a master slave manipulator system for space use p 86 A88-26975
Telepresence work station system definition study, part 2
[NASA-CR-172006] p 4 N88-10071
Space station platforms p 116 N88-10086
Telerobotics p 86 N88-10090
Robotic sensors and actuators for a service manipulator system. Volume 1: Executive summary
[MATRA-EPT/DT/VT187/120] p 87 N88-10341
Robotic sensors and actuators for a service manipulator system. Volume 2: Service Manipulator System (SMS) handbook
[MATRA-EPT/DT/VT187/227] p 87 N88-10342
Robotic sensors and actuators for a service manipulator system. Volume 3, phase A report and program plan
[MATRA-EPT/DT/VT187/228] p 87 N88-10343
Teleoperator and robotics system analysis
[NASA-CR-179220] p 87 N88-12105
National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 1
[NASA-CR-172009-VOL-1] p 166 N88-14855
National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 2
[NASA-CR-172009-VOL-2] p 166 N88-14874
Dynamics, control and sensor issues pertinent to robotic hands for the EVA retriever system p 88 N88-14878
Advancing automation and robotics technology for the space station and for the US economy: Submitted to the United States Congress October 1, 1987
[NASA-TM-100777] p 88 N88-15815
Advancing automation and robotics technology for the space station and for the US economy: Submitted to the United States Congress May 15, 1987
[NASA-TM-89811] p 88 N88-15817
Advancing automation and robotics technology for the space station and for the US economy: Submitted to the United States Congress October 1, 1986
[NASA-TM-89190] p 89 N88-15818
Third Conference on Artificial Intelligence for Space Applications, part 1
[NASA-CP-2492-PT-1] p 89 N88-16360
Telerobotic controller development p 89 N88-16370
Goal driven kinematic simulation of flexible arm robot for space station missions p 89 N88-16388
Vision technology/algorithms for space robotics applications p 90 N88-17267
NASA/NBS (National Aeronautics and Space Administration/National Bureau of Standards) standard reference model for Telerobot Control System Architecture (NASREM)
[PB88-124773] p 92 N88-17999
Robotic intelligence issues for space manipulator monitoring, control programming p 92 N88-19504
On a knowledge based assisted system for highly autonomous control of experiment-manipulators in the Man-Tended Free Flyer p 92 N88-19505
A knowledge-based approach for sensory-controlled assembly operations p 128 N88-19506
Mobile robot activity model for autonomous free flying platforms p 92 N88-19507
EPOS: European Proximity Operations Simulation p 147 N88-19515
Utilization of robotics and teleoperation for future in-orbit operations p 93 N88-19527
Robotics servicing experiment — European space programs p 93 N88-19529
Definition of the EUROSIM simulation subsystem p 148 N88-19532
A comparative survey of mathematical models for dynamic simulation of in-orbit manipulation operations p 148 N88-19533
Technology requirements for telerobotic satellite servicing in space p 93 N88-19536
Man-tended options for European space robotics p 94 N88-19538

ROBOTS
Semiautonomous control for satellite servicing
[AIAA PAPER 87-2952] p 81 A88-12573

Modeling and simulation of distributed flexibility in a spaceborne manipulator p 83 A88-16309
Robots - Autonomous space workers p 84 A88-19866
The use of computer graphic simulation in the development of on-orbit tele-robotic systems p 85 A88-21646
An orbiting control station for free-flying teleoperators - Preliminary design methodology p 51 A88-21647
A technique to aid in the design of optimal robots for use in space applications p 85 A88-21648
System architecture for telerobotic servicing and assembly tasks p 85 A88-21649
Computing architecture for telerobots in earth orbit p 99 A88-21650
The NASA telerobot technology demonstrator p 85 A88-21651
Robotic sensors and actuators for a service manipulator system. Volume 1: Executive summary [MATRA-EPT/DT/VT187/120] p 87 N88-10341
Robotic sensors and actuators for a service manipulator system. Volume 2: Service Manipulator System (SMS) handbook [MATRA-EPT/DT/VT187/227] p 87 N88-10342
Robotic sensors and actuators for a service manipulator system. Volume 3, phase A report and program plan [MATRA-EPT/DT/VT187/229] p 87 N88-10343
Traction-drive seven degrees-of freedom telerobot arm: A concept for manipulation in space [DE87-010895] p 87 N88-10346
Teleoperation and control study --- orbital servicing [BAE-TP-8268] p 87 N88-10489
Cartesian path control of a two-degree-of-freedom robot manipulator [NASA-CR-182231] p 88 N88-13908
Goal driven kinematic simulation of flexible arm robot for space station missions p 89 N88-16388
Solid modeling for the manipulative robot arm (power) and adaptive vision control for space station missions p 89 N88-16409
Planning and scheduling for robotic assembly p 90 N88-16416
Telerobotic research at NASA Langley Research Center p 91 N88-17269
Manipulator arm design for the Extravehicular Teleoperator Assist Robot (ETAR): Applications on the space station p 91 N88-17270
Telerobotic truss assembly p 91 N88-17272
Crew interface with a telerobotic control station p 91 N88-17273
Telerobot for space station p 91 N88-17274
Task-level robot programming: Integral part of evolution from teleoperation to autonomy p 91 N88-17279
In-orbit automatic assembly of reticular structures p 92 N88-19491
Mobile robot activity model for autonomous free flying platforms p 92 N88-19507
Remote manipulation in orbital construction, servicing and repair missions: Is one arm enough? A comparative evaluation of the performance features of robots with one or more arms p 93 N88-19509
Covariant control of bilateral servos for in-orbit manipulation p 62 N88-19520

ROBUSTNESS (MATHEMATICS)
Robustness of active modal damping of large flexible structures p 11 A88-13929
Structural decomposition approach to design of robust decentralized controllers for large scale systems p 53 A88-27358
Lyapunov function gradient generated robust control in the absence of the nominal stabilizing control p 54 A88-27404
New feedback design methodologies for large space structures: A multi-criterion optimization approach p 59 N88-12535
Maximum entropy/optimal projection design synthesis for decentralized control of large space structures [AD-A186359] p 29 N88-15003

ROCKET ENGINES
Orbital Maneuvering Vehicle (OMV) propulsion subsystem [IAF PAPER 87-261] p 149 A88-15976
A life test of a 22-Newton (5-lbf) hydrazine rocket [NASA-TM-100232] p 79 N88-11750

ROCKET EXHAUST
True energy atmospheric simulator for low earth orbit species [AIAA PAPER 88-0727] p 3 A88-22549

ROCKET PROPELLANTS
Orbital Spacecraft Consumables Resupply System (OSCRS). Volume 2: Study results [NASA-CR-172011] p 126 N88-11687
A life test of a 22-Newton (5-lbf) hydrazine rocket [NASA-TM-100232] p 79 N88-11750
Compatability of dispersion-strengthened platinum with resistojet propellants [NASA-TP-2765] p 79 N88-12538
Space station onboard propulsion system: Technology study [NASA-CR-179233] p 80 N88-15006

ROCKET SOUNDING
Results from a series of tethered rocket experiments p 111 A88-18834

ROCKET THRUST
Space station propulsion technology [NASA-CR-179260] p 80 N88-15835

ROTARY GYROSCOPES
Attitude control of a three-rotor gyrostat in the presence of uncertainty p 52 A88-22933

ROTARY STABILITY
Rotation stability of a deformable flight vehicle p 144 A88-30115

ROTATING BODIES
Construction of a full solution for an integrable case of the problem of the motion of two coupled bodies p 115 A88-26687
Construction of a full solution to the problem of the relative motion of a system of two bodies p 115 A88-26688

ROTATION
Three-axis rotational maneuver and vibration stabilization of elastic spacecraft p 54 A88-27364
Analysis of a rotating advanced technology space station for the year 2025 [NASA-CR-178345] p 107 N88-19580

ROUND TRIP TRAJECTORIES
Mission profiles of the MTFF co-orbiting with the US Space Station p 6 N88-14487

S

SAFETY FACTORS
Crewman rescue equipment in manned space missions - Aspects of application [IAF PAPER 87-576] p 153 A88-16187
Safety philosophy, policy, and requirements for manned spaceflight. Volume 1: Executive summary [HEG-0886/1036-VOL-1] p 157 N88-15826

SAFETY MANAGEMENT
Experiments to ensure Space Station fire safety - A challenge [AIAA PAPER 88-0540] p 155 A88-22405

SALYUT SPACE STATION
Men in space --- Salyut 7 cosmonaut EVA operations [IAF PAPER 87-77] p 162 A88-15952
Experience of the Salyut-7 propulsion system (PS) repair operations [IAF PAPER 87-87] p 137 A88-15861
Intercosmos: An example of cooperation --- Russian book p 142 A88-24793
Repair of Salyut 7 p 143 A88-25943
Determination of cosmic-ray characteristics on Salyut-7 p 131 A88-28349
Basic results of medical studies during prolonged manned flights on-board the Salyut-7/Soyuz-T orbital complex [NASA-TT-20217] p 147 N88-18182

SANDWICH STRUCTURES
Mechanical properties characterization of composite sandwich materials intended for space antenna applications [NASA-TM-88893] p 25 N88-10121

SATELLITE ALTIMETRY
Swath altimetry of oceans and terrain p 115 A88-27838

SATELLITE ANTENNAS
Analytical and experimental investigations for satellite antenna deployment mechanisms [AIAA PAPER 88-2225] p 76 A88-32189
Studies of the structural dynamic behavior of satellite antenna system [AD-A185526] p 28 N88-14121
Space environmental effects on polymeric materials [NASA-CR-182418] p 97 N88-15082

SATELLITE ATTITUDE CONTROL
Application of magnetic bearings to high-torque, satellite attitude control wheels p 47 A88-11908
Development experience of the attitude control system using single-axis control moment gyros for long-term orbiting space stations [IAF PAPER 87-04] p 48 A88-15804
An optically tethered and controlled satellite system [IAF PAPER 87-50] p 109 A88-15835
Solar sailing attitude control of large geostationary satellite p 50 A88-16280
Fault tolerant onboard implementation of control procedures in tethered satellite p 110 A88-16285
Mathematical models of flexible spacecraft dynamics - A survey of order reduction approaches p 13 A88-16293
Minimum time attitude slewing maneuvers of a rigid spacecraft [AIAA PAPER 88-0675] p 52 A88-22505
Attitude control of a three rotor gyrostat in the presence of uncertainty p 52 A88-22933
An experimental study on flexible spacecraft three-axis attitude control p 53 A88-26356
Momentum management and attitude control design for a Space Station p 55 A88-26253
Construction aspects of testbeds for attitude control systems simulation of artificial satellites [INPE-4283-PRE/1155] p 61 N88-18616
Simulation and tests of a satellite attitude and orbit control system. General considerations concerning an example case (INPE) and design of a servo rate table [INPE-4282-PRE/1154] p 62 N88-19572

SATELLITE COMMUNICATION
Geostationary tether satellite system and its application to communications systems p 115 A88-28974
An allotment planning concept and related computer software for planning the fixed satellite service at the 1988 space WARC [NASA-TM-100244] p 165 N88-11944

SATELLITE CONTROL
Dynamics and control of the tethered satellite system in the presence of offsets [IAF PAPER 87-316] p 109 A88-16014
Evaluation of control concepts for a large geostationary data relay satellite p 50 A88-16281
On control of tethered satellite systems p 110 A88-16294
Dynamics and control of the Tethered Satellite System in the presence of offsets p 112 A88-20036

SATELLITE DESIGN
The DFS platform and its applications --- German communication satellite [IAF PAPER 87-470] p 138 A88-16119
Economic benefits of the Space Station to commercial communication satellite operators [IAF PAPER 87-622] p 163 A88-16215
The GSFC Flight Support System for on-orbit satellite servicing [AIAA PAPER 88-0448] p 124 A88-22334
Tethers in space - A broad perspective [AIAA PAPER 88-0530] p 113 A88-22396
Mechanical design of the ac bracket package for the RETE experiment [IFSI-87-4] p 145 N88-13379

SATELLITE GROUND SUPPORT
Future European ground segment --- to support earth observation satellites p 133 A88-15279
Space Station ground data management system p 98 A88-15282

SATELLITE IMAGERY
SPOT 1 - Earth observing satellite p 3 A88-26186

SATELLITE LIFETIME
Artificial space debris --- Book p 130 A88-17944

SATELLITE NETWORKS
Study of mobile communications payload for Columbus Polar Platforms [ITS-TR-056A/88] p 76 N88-10220
Interoperability and integration of data relay satellite systems p 76 N88-12134

SATELLITE OBSERVATION
Observations of ocean and sea bottom relief from space p 143 A88-26099
SPOT 1 - Earth observing satellite p 3 A88-26186
USSR report: Space [JPRS-USP-87-003] p 144 N88-10050

SATELLITE ORBITS
The GSFC Flight Support System for on-orbit satellite servicing [AIAA PAPER 88-0448] p 124 A88-22334
Dynamics of earth-orbiting flexible satellites with multibody components p 52 A88-22609

SATELLITE ORIENTATION
Video-based satellite attitude determination p 51 A88-21657

SATELLITE PERTURBATION
Angular momentum management for LEO platforms [IAF PAPER 87-349] p 49 A88-16039

SATELLITE POWER TRANSMISSION (TO EARTH)
ESA Bulletin No. 25 [ISSN-0376-4265] p 146 N88-16767
Satellite power systems under consideration by the United Nations p 74 N88-16773

SATELLITE ROTATION
Capture-ejector satellites p 108 A88-11726
Construction of a full solution for an integrable case of the problem of the motion of two coupled bodies p 115 A88-26687

SATELLITE SOLAR ENERGY CONVERSION
Optimization of the parameters of a solar photoelectric system exposed to cosmic rays p 72 A88-26250
SATELLITE SOLAR POWER STATIONS
Space solar cell research - Problems and potential p 70 A88-21605
SATELLITE SOUNDING
Reconstruction of the vertical atmospheric temperature profile on the basis of refraction measurements from the Salyut-7 orbital station p 131 A88-23930
Stratospheric luminescence observed from the Salyut-7 station p 144 A88-30076
SATELLITE TRANSMISSION
Simple analysis of Space Station downlinks p 100 A88-30185
SATELLITE-BORNE INSTRUMENTS
Development of on-board satellite communications equipment in the Geostationary Platform era [IAF PAPER 87-495] p 110 A88-16136
SCALE MODELS
Space Station - A focus for the development of structural dynamics scale model technology for large flexible space structures [AIAA PAPER 88-2483] p 19 A88-31392
Analytical investigation of the dynamics of tethered constellations in Earth orbit (phase 2) [NASA-CR-179218] p 117 N88-12533
SCALING LAWS
Verification of large beam-type space structures p 14 A88-18637
SCATHA SATELLITE
Observations of ions generated on or near satellite surfaces [AIAA PAPER 88-0434] p 130 A88-22323
SCATTEROMETERS
Study of a payload for Columbus Polar Platform Earth observation demonstration mission, executive summary [ESA-CR(P)-2412] p 116 N88-10079
SCAVENGING
Atmospheric science p 5 N88-15357
STS propellant scavenging systems study. Part 2, volume 2: Cost and WBS/dictionary [NASA-CR-179276] p 61 N88-17717
SCHEDULING
Power and resource management scheduling for scientific space platform applications p 108 A88-11880
Cooperating expert systems for power systems -- Space Station resource allocation p 68 A88-11881
Third Conference on Artificial Intelligence for Space Applications, part 1 [NASA-CP-2492-Pt-1] p 99 N88-16360
Knowledge-based simulation p 102 N88-16404
Planning and scheduling for robotic assembly p 90 N88-16416
An AI approach for scheduling space-station payloads at Kennedy Space Center p 90 N88-16425
The resource envelope as a basis for space station management system scheduling p 102 N88-16427
Prototype resupply scheduler p 9 N88-16428
SCIENTIFIC SATELLITES
Report on the scientific satellites of the European Space Agency [ESA-SP-1090] p 116 N88-10081
SCIENTISTS
Report from the MPP Working Group to the NASA Associate Administrator for Space Science and Applications [NASA-TM-87819] p 100 N88-11402
SECONDARY EMISSION
External surface charging mechanisms -- spacecraft p 132 N88-11719
SELF ADAPTIVE CONTROL SYSTEMS
Wavefront error sensing [NASA-CR-181504] p 76 N88-12030
SELF SHADOWING
Self-shadowing effects on the thermal-structural response of orbiting trusses p 32 A88-11734
SENSORS
Sensor and actuator selection for optimal closed-loop performance in the presence of correlated noise p 54 A88-27397
SEQUENCING
PLAN-IT - Knowledge-based mission sequencing p 7 A88-21844
SERVICE LIFE
Hubble Space Telescope servicing - Experience base for a new era [IAF PAPER 87-38] p 109 A88-15828
Thermal control definition of Columbus pressurized modules [SAE PAPER 871483] p 139 A88-21138
NASA spaceborne optical disk recorder development p 100 A88-29820
Long-life assurance for Space Station - Is it an issue? [AIAA PAPER 88-2489] p 43 A88-31398
Space station propulsion [NASA-TM-100216] p 79 N88-11746
SERVICE MODULES
European retrievable carrier Eureca servicing by Hermes p 139 A88-21416
SERVOCONTROL
Covariant control of bilateral servos for in-orbit manipulation p 62 N88-19520
SERVOMECHANISMS
Covariant control of bilateral servos for in-orbit manipulation p 62 N88-19520
SHAPE CONTROL
On the modeling and control of a flexible manipulator arm by point actuators p 82 A88-14996
Development of the Mast Flight System linear dc motor inertial actuator [AAS PAPER 87-021] p 13 A88-16990
Techniques for assessment of flexible space structure control performance [AIAA PAPER 88-0677] p 52 A88-22507
Decentralized/hierarchical control for large flexible spacecraft [MBB-UR-967-87] p 52 A88-23982
A criterion for shape control robustness of space structures p 16 A88-29720
Multisurface control mechanism for a deployable antenna. Far Infrared and Submillimeter Space Telescope (FIRST) technology study [RP-FA-D003] p 120 N88-16807
SIDELOBES
Compensation of reflector antenna surface distortion using an array feed [NASA-TM-100286] p 77 N88-19805
SIGNAL ANALYSIS
A model-free method for mass spectrometer response correction -- for oxygen consumption and cardiac output calculation p 111 A88-19683
SIGNAL MEASUREMENT
Wave propagation experiments on 22-bay lattice [AD-A186110] p 29 N88-15002
SIGNAL RECEPTION
Automatic antenna switching design for Extra Vehicular Activity (EVA) communication system p 77 N88-14883
SIMULATION
Large space structures testing [AAS PAPER 87-036] p 13 A88-16996
Fourteenth Space Simulation Conference: Testing for a Permanent Presence in Space [NASA-CP-2446] p 5 N88-10829
Feasibility study for gas-grain simulation facility [NASA-CR-177468] p 28 N88-13954
Development of an emulation-simulation thermal control model for space station application [NASA-CR-182409] p 37 N88-15823
Simulation and tests of a satellite attitude and orbit control system. General considerations concerning an example case (INPE) and design of a servo rate table [INPE-4282-PRE/1154] p 62 N88-19572
Full scale architectural simulation techniques for space stations p 10 N88-19887
OMV man/system simulation integration: A preliminary analysis and recommendation [NASA-CR-182602] p 151 N88-20005
SINGLE STAGE TO ORBIT VEHICLES
A conceptual design for a single-stage-to-orbit Space Station Service Vehicle [IAF PAPER 87-ST-07] p 2 A88-16071
A conceptual design for a single-stage-to-orbit Space Station service vehicle [AIAA PAPER 88-0089] p 3 A88-22063
SINGULARITY (MATHEMATICS)
On the hierarchical control of the Space Station common module thermal system p 33 A88-14980
SIZE (DIMENSIONS)
Estimating payload internal temperatures and radiator size for multimegawatt space platforms [DE88-000244] p 37 N88-11738
SLEWING
Dynamics and control during slewing maneuvers [IAF PAPER 87-353] p 49 A88-16043
Mission function control applied to slew maneuver [IAF PAPER 87-354] p 49 A88-16044
Minimum time attitude slewing maneuvers of a rigid spacecraft [AIAA PAPER 88-0675] p 52 A88-22505
Dynamics of spacecraft control laboratory experiment (SCOLE) slew maneuvers [NASA-CR-4098] p 57 N88-10082
Recent advances in structural dynamics of large space structures [NASA-TM-100513] p 26 N88-10867
Combined problem of slew maneuver control and vibration suppression [NASA-CR-181537] p 59 N88-12817
The dynamics and control of large flexible space structures, part 10 [NASA-CR-182426] p 29 N88-15830
Large-angle slewing maneuvers for flexible spacecraft [NASA-CR-4123] p 60 N88-16010
SMALL SCIENTIFIC SATELLITES
Minibooka X-ray detector and spacecraft design study p 108 A88-15511
SMOKE
A smoke removal unit [SAE PAPER 871449] p 153 A88-21109
SOCIAL FACTORS
The role of psychologists in future spaceflight p 159 A88-10958
Small groups in orbit - Group interaction and crew performance on Space Station p 151 A88-15348
Social factors in space station interiors p 46 N88-19888
SOFTWARE ENGINEERING
Space Station Mission Planning System (MPS) development study. Volume 1: Executive summary [NASA-CR-179202] p 4 N88-10047
Space Station Mission Planning System (MPS) development study. Volume 2 [NASA-CR-179200] p 4 N88-10048
Space Station Mission Planning Study (MPS) development study. Volume 3: Software development plan [NASA-CR-179203] p 4 N88-10049
Attitude Control Working Group report p 57 N88-10009
An allotment planning concept and related computer software for planning the fixed satellite service at the 1988 space WARC [NASA-TM-100244] p 165 N88-11944
Approaches and possible improvements in the area of multibody dynamics modeling [NASA-CR-179227] p 28 N88-14067
National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 2 [NASA-CR-172009-VOL-2] p 166 N88-14874
Space station software reliability analysis based on failures observed during testing at the multisystem integration facility p 101 N88-14884
Robotic intelligence issues for space manipulator monitoring, control programming p 92 N88-19504
EUROSIM: A design concept for an in-orbit operations simulator p 148 N88-19517
Definition of the EUROSIM simulation subsystem p 148 N88-19532
SOFTWARE TOOLS
Translation and execution of distributed Ada programs - Is it still Ada? p 7 A88-21643
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems [NASA-TM-89705] p 88 N88-15497
SOLAR ARRAYS
Advanced photovoltaic solar array design p 63 A88-11793
Spacecraft solar array substrate development p 68 A88-12187
Large flexible solar arrays p 11 A88-15277
Past, present, and future activities in space power technology in the United States of America [IAF PAPER 87-245] p 69 A88-15966
Deployment dynamics of accordian type of deployable solar arrays considering flexibility of closed control loops [IAF PAPER 87-256] p 11 A88-15974
Stress and deformation analysis and tests of composite structures for space application [IAF PAPER 87-312] p 12 A88-16011
Modal damping measurement of MOS-1 Solar Array Paddle p 13 A88-16292
A free-flying power plant for a manned space station p 70 A88-16309
Fokker subsystem responsibilities in Columbus B phase studies p 141 A88-21561
Numerical analysis of interaction of a high-voltage solar array with ionospheric plasma p 72 A88-27588
Phase 3 study of selected tether applications in space. Volume 2: Study results [NASA-CR-179186] p 116 N88-10828
Environmental interactions of solar generators in space p 72 N88-11730
The high performance solar array GSR3 [SNIAS-872-422-108] p 73 N88-13814
Study of large solar arrays (SOLA), phase 2A [BAE-SS/1109] p 74 N88-17106
Study of Large Solar Arrays (SOLA). Phase 2A: Amplifying information to final report (SS/1109) [BAE-SS/1110] p 74 N88-17480

Oxidation and protection of fiberglass-epoxy composite masts for photovoltaic arrays in the low Earth orbital environment
[NASA-TM-100839] p 97 N88-18734
Mast material test program (MAMATEP)
[NASA-TM-100821] p 31 N88-19592

SOLAR CELLS
Past, present and future activities in space power technology in the UK
[IAF PAPER 87-243] p 69 A88-15964
Photovoltaics for commercial solar power applications; Proceedings of the Meeting, Cambridge, MA, Sept. 18, 19, 1986
[SPIE-706] p 70 A88-21601
Space solar cell research - Problems and potential p 70 A88-21605
The high performance solar array GSRO
[SNIAS-872-422-108] p 73 N88-13814

SOLAR COLLECTORS
Solar receiver for the Space Station Brayton engine
[ASME PAPER 87-GT-252] p 62 A88-11134
Solar concentrator advanced development project p 64 A88-11799
Advanced solar receiver conceptual design study p 64 A88-11800
Development of an advanced photovoltaic concentrator system for space applications p 65 A88-11812
Collector and receiver designs for high temperature Brayton cycle for space application
[IAF PAPER 87-229] p 69 A88-15952
Development of composite facets for the surface of a space-based solar dynamic concentrator p 70 A88-18230

SOLAR CORONA
Astrophysics and the solar nebula p 118 N88-15355
Exobiology and life science p 118 N88-15356

SOLAR DYNAMIC POWER SYSTEMS
Toluene stability Space Station Rankine power system p 63 A88-11794
Binary mercury/organic Rankine cycle power systems p 63 A88-11795
Ross-Stirling engine - A high performance dynamic space power system p 63 A88-11797
Advanced space solar dynamic power systems beyond IOC Space Station p 64 A88-11798
Solar concentrator advanced development project p 64 A88-11799
Advanced solar receiver conceptual design study p 64 A88-11800
Selection of high temperature thermal energy storage materials for advanced solar dynamic space power systems p 64 A88-11801
Integrated heat pipe-thermal storage system performance evaluation p 32 A88-11803
Fluoride salts and container materials for thermal energy storage applications in the temperature range 973 - 1400 K p 32 A88-11804
Impact of thermal energy storage properties on solar dynamic space power conversion system mass p 64 A88-11805
Heat pipe radiators for solar dynamic space power system heat rejection p 33 A88-11807
Solar dynamic organic Rankine cycle heat rejection system simulation p 65 A88-11808
Reliability models for Space Station power system p 65 A88-11815
Collector and receiver designs for high temperature Brayton cycle for space application
[IAF PAPER 87-228] p 69 A88-15953
Optical measurements pertaining to Space Station solar dynamic power systems
[IAF PAPER 87-229] p 69 A88-15954
Space Station Electrical Power System
[IAF PAPER 87-234] p 69 A88-15958
Modeling the performance of the monogroove with screen heat pipe for use in the radiator of the solar dynamic power system of the NASA Space Station
[IAF PAPER 87-238] p 34 A88-15960
Development of composite facets for the surface of a space-based solar dynamic concentrator p 70 A88-18230
Oxidation-resistant reflective surfaces for solar dynamic power generation in near earth orbit p 70 A88-18523
Solar dynamic heat receiver thermal characteristics in low earth orbit
[AIAA PAPER 88-0472] p 71 A88-22348
Structural assessment of a Space Station solar dynamic heat receiver thermal energy storage canister
[AIAA PAPER 88-2487] p 72 A88-31396
Photovoltaic power modules for NASA's manned space station
[NASA-TM-100229] p 72 N88-11745
Status of 20 kHz space station power distribution technology
[NASA-TM-100781] p 73 N88-15838
Solar concentrator advanced development program, task 1
[NASA-CR-179489] p 74 N88-18068
Computer-aided modeling and prediction of performance of the modified Lundell class of alternators in space station solar dynamic power systems
[NASA-CR-182538] p 74 N88-19000

SOLAR ELECTRIC PROPULSION
Solar- and nuclear electric propulsion for high energy orbits
[IAF PAPER 87-196] p 77 A88-15935

SOLAR ENERGY
Impact of thermal energy storage properties on solar dynamic space power conversion system mass p 64 A88-11805
Preliminary conceptual design and weight of a one-megawatt space-based laser power station utilizing a solar-pumped iodine lasant p 65 A88-11816
Definition and economic evaluation of Space Solar Power Systems (SSPS), part 1
[ILR-MITT-184-1(1987)] p 73 N88-16189
Definition and economic evaluation of Space Solar Power Systems (SSPS), part 2
[ILR-MITT-184-2(1987)] p 73 N88-16190

SOLAR GENERATORS
Radiator selection for Space Station Solar Dynamic Power Systems p 32 A88-11806
Performance characteristics of a combination solar photovoltaic heat engine energy converter p 65 A88-11813
High thermal-transport capacity heat pipes for space radiators
[SAE PAPER 871509] p 35 A88-21155
Solar dynamic heat receiver thermal characteristics in low earth orbit
[AIAA PAPER 88-0472] p 71 A88-22348
Solar thermodynamic power systems in space p 72 A88-26153
Environmental interactions of solar generators in space p 72 N88-11730
Solar converging method p 37 N88-12504
Definition and economic evaluation of Space Solar Power Systems (SSPS), part 1
[ILR-MITT-184-1(1987)] p 73 N88-16189
Definition and economic evaluation of Space Solar Power Systems (SSPS), part 2
[ILR-MITT-184-2(1987)] p 73 N88-16190

SOLAR HEATING
Self-shadowing effects on the thermal-structural response of orbiting trusses p 32 A88-11734
Solar dynamic heat receiver thermal characteristics in low earth orbit
[AIAA PAPER 88-0472] p 71 A88-22348

SOLAR MAXIMUM MISSION
Technology advancements for servicing of future spacecraft systems
[IAF PAPER 87-36] p 122 A88-15826
The Solar Maximum Mission repair - Lessons learned p 124 A88-21653
In-orbit and laboratory exchange of ORUs designed/not designed for servicing p 151 N88-19499
Remote repair demonstration of Solar Maximum main electronics box p 128 N88-19510

SOLAR MESOSPHERE EXPLORER
Lowering the costs of satellite operations - Lessons learned from the Solar Mesosphere Explorer (SME) mission
[AIAA PAPER 88-0549] p 7 A88-22412

SOLAR PHYSICS
Research and technology, 1987
[NASA-TM-100323] p 167 N88-20253

SOLAR POWER SATELLITES
Laser solar power satellites - A case study in technology forecasting p 68 A88-15492
A general truss system for very large space base foundations, with application to the solar power satellite
[IAF PAPER 87-248] p 11 A88-15967
Dynamic power generation for solar power satellites
[IAF PAPER 87-253] p 69 A88-15972
Solar power satellites p 70 A88-17023
Solar power satellites - Still in the dark p 70 A88-19002
Solar-thermodynamic power systems in space p 72 A88-26150

SOLAR PROPULSION
Solar sails and the Arsal satellite - Scientific applications and techniques p 106 A88-28864

SOLAR RADIATION
The dynamics and control of large space structures after the onset of thermal shock
[IAF PAPER 87-351] p 49 A88-16041
Solar plant growth facility (SPGF) - An approach toward future biological life support systems p 155 A88-29141

SOLAR REFLECTORS
Solar converging method p 37 N88-12504

SOLAR SAILS
Solar sailing attitude control of large geostationary satellite p 50 A88-16260
Solar sails and the Arsal satellite - Scientific applications and techniques p 106 A88-28864

SOLAR SIMULATION
ESA Bulletin No. 25
[ISSN-0376-4265] p 146 N88-16767

SOLAR SYSTEM
Long-term strategy of space science in Japan p 143 A88-29195

SOLAR TERRESTRIAL INTERACTIONS
Solar power satellites p 70 A88-17023
Solar-terrestrial research in the space station era p 116 N88-10747
Space Environment Technology --- conference
[ISBN-2-85428-170-5] p 132 N88-11702

SOLAR THERMAL ELECTRIC POWER PLANTS
Definition and economic evaluation of Space Solar Power Systems (SSPS), part 1
[ILR-MITT-184-1(1987)] p 73 N88-16189
Definition and economic evaluation of Space Solar Power Systems (SSPS), part 2
[ILR-MITT-184-2(1987)] p 73 N88-16190

SOLAR THERMAL PROPULSION
Solar-thermal OTVs in comparison with electrical and chemical propulsion systems
[IAF PAPER 87-199] p 77 A88-15936

SOLAR WIND
Plasmoid power station
[IAF PAPER 87-250] p 69 A88-15969

SOLID STATE LASERS
Laser Docking System Radar flight experiment p 47 A88-12814

SOLID WASTES
OSSA Space Station waste inventory
[SAE PAPER 871413] p 39 A88-21078

SOVIET SPACECRAFT
Listening to the cosmonauts p 75 A88-13975
USSR export possibilities in the field of space hardware
[SAE PAPER 871342] p 133 A88-14368
Results of medical investigations conducted aboard the 'Salyut-6'-'Soyuz' orbital research complex --- Russian book p 135 A88-15650
The beginning of the Mir station active operation
[IAF PAPER 87-84] p 136 A88-15858
Simple analysis of Space Station downlinks p 100 A88-30189

SOYUZ SPACECRAFT
Soyuz enters third decade p 139 A88-16709
USSR report: Space
[JPRS-USP-87-003] p 144 N88-10050
Basic results of medical studies during prolonged manned flights on-board the Salyut-7/Soyuz-T orbital complex
[NASA-TT-20217] p 147 N88-18182

SPACE ADAPTATION SYNDROME
Cardiovascular adaptation to zero-g during a long term flight (237 days) on board the Salyut 7 Soviet space station (1984) p 158 N88-19920
Cardiac and peripheral circulation assessment by ultrasound on 3 astronauts during two 7-day space flights (1982 Salyut-7 - 1985 STS 51G) p 158 N88-19921

SPACE COLONIES
Two days to Mars with fusion propulsion p 78 A88-29236
Space farming in the 21st century p 106 A88-29237

SPACE COMMERCIALIZATION
Has manned space flight a future? p 159 A88-10850
The commercial use of space stations: The legal framework of trans-Atlantic cooperation; International Colloquium, Hanover, Federal Republic of Germany, June 12, 13, 1986, Reports
[DGLR BERICHT 86-02] p 160 A88-13443
Business issues of materials processing in space p 160 A88-13451
Legal problems of the commercial use of space stations including proprietary rights p 160 A88-13452
Proprietary rights and commercial use of space stations p 161 A88-13453
A model for enveloping Space Station logistics requirements p 102 A88-15286
Thirty years of the space age p 162 A88-16074
Spacehab's commercialization of microgravity research activities
[IAF PAPER 87-629] p 110 A88-16221
Industrial Space Facility
[AIAA PAPER 88-0649] p 3 A88-22484
The civil space program: An investment in America - Report of an AIAA Workshop p 164 A88-23925
U.S. Space Platform firms aim for 1991 service start p 164 A88-27954

205

Space station: Leadership for the future
[NASA-PAM-509/8-87] p 165 N88-10072
Moving the factory into orbit p 165 N88-10844
Commercial Opportunities for Remote Sensing with Polar Platforms
[ESA-SP-269] p 117 N88-12131
Possible commercial use of the polar platforms — Columbus p 165 N88-12132
Commercial perspective of an imaging spectrometer development program p 165 N88-12136
Definition and economic evaluation of Space Solar Power Systems (SSPS), part 2
[LR-MTT-184-2(1987)] p 73 N88-16190

SPACE COMMUNICATION
Prospects on future EVA communications
[AIAA PAPER 88-0767] p 76 A88-27542
High data rate modem simulation for the space station multiple-access communications system p 101 N88-14870

SPACE DEBRIS
Dynamics of orbiting debris clouds and the resulting collision hazard to spacecraft
[IAF PAPER 87-571] p 129 A88-16183
Department of Defense space policy and the development of a global policy for the control of space debris
[IAF PAPER 87-575] p 129 A88-16186
Artificial space debris — Book p 130 A88-17944
The dangers of space debris - New developments and discoveries p 130 A88-18398
Debris hazard poses future threat p 131 A88-24846
Space Station probability of no penetration due to meteoroid and orbital debris impact
[AIAA PAPER 88-2464] p 18 A88-31387
Space environmental considerations for a long-term cryogenic storage vessel p 80 N88-15933
Space station integrated wall damage and penetration damage control. Task 5: Space debris measurement, mapping and characterization system
[NASA-CR-179281] p 30 N88-17688

SPACE ENVIRONMENT SIMULATION
An innovative exercise method to simulate orbital EVA work - Applications to PLSS automatic controls
[SAE PAPER 871475] p 154 A88-21130
Tether Dynamics Simulation Workshop summary
[AIAA PAPER 88-0531] p 113 A88-22397
True energy atmospheric simulator for low earth orbit species
[AIAA PAPER 88-0727] p 3 A88-22549
Structural testing on the multi-axis simulator - An innovative simulation system for space-vehicle structures p 17 A88-29725
Response of composite materials to the Space Station orbit environment
[AIAA PAPER 88-2476] p 95 A88-31390
EPOS - A facility for simulating operations near spacecraft p 56 A88-32145
Laboratory simulation of the electrodynamic interactions of a tethered satellite with an ionospheric plasma
[IFSI-86-3] p 119 N88-15822
EUROSIM: A design concept for an in-orbit operations simulator p 148 N88-19517

SPACE ERECTABLE STRUCTURES
Large inflatable, space-rigidized antenna reflectors - Land mobile services development
[IAF PAPER 87-315] p 12 A88-16013
Two-dimensionally deployable 'SHOF' truss
[IAF PAPER 87-319] p 12 A88-16017
Radiation characteristics of offset radial rib reflector antennas p 34 A88-17566
Space erectable radiator system development
[AIAA PAPER 88-0469] p 36 A88-22345
A telescope for high energy gamma-ray measurements in the Space Station era
[AIAA PAPER 88-0652] p 114 A88-22485
Shuttle based assembly of Space Station
[AIAA PAPER 88-2452] p 125 A88-31379
Design and development of the truss assembly fixture for Space Station assembly operations
[AIAA PAPER 88-2455] p 18 A88-31380
Astronaut/EVA construction of Space Station
[AIAA PAPER 88-2459] p 125 A88-31382
Nondestructive construction error detection in large space structures
[AIAA PAPER 88-2460] p 18 A88-31383
Analytical and experimental investigations for satellite antenna deployment mechanisms
[AIAA PAPER 88-2225] p 75 A88-32189
Access flight hardware design and development p 26 N88-10873
Planning and scheduling for robotic assembly p 90 N88-16418
Satellite assembly in geostationary orbit: A plug-and-socket concept p 127 N88-16769
Space station structures development
[NASA-CR-179261] p 30 N88-16792
The integration of a mesh reflector to a 15-foot box truss structure. Task 3: Box truss analysis and technology development
[NASA-CR-178226] p 31 N88-18941

SPACE EXPLORATION
Pathfinder technologies for bold new missions — U.S. research and development program for space exploration
[IAF PAPER 87-46] p 1 A88-15832
Thirty years of the space age p 162 A88-16074
Proceedings of the Fourth Annual L5 Space Development Conference p 163 A88-22090
Space near and far — Russian book p 143 A88-27734
Long term strategy of space science in Japan p 143 A88-29195
Mankind and space — Russian book p 164 A88-29410
USSR report: Space
[JPRS-USP-87-003] p 144 N88-10050
America plans for space
[AD-A187465] p 167 N88-17713

SPACE FLIGHT
Crew productivity issues in long-duration space flight
[AIAA PAPER 88-0444] p 154 A88-22330
Planning framework for high-technology space flight (OHR) p 142 A88-23516

SPACE FLIGHT FEEDING
Power requirements for an orbiting space farm
[IAF PAPER 87-242] p 70 A88-15969
National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 1
[NASA-CR-172009-VOL-1] p 166 N88-14955
The determination of nutritional requirements for Safe Haven Food Supply System (emergency/survival foods) p 45 N88-14956
Design concepts for bioreactors in space p 45 N88-17179

SPACE FLIGHT STRESS
Bones and stones in space - Integrating the medical and scientific questions
[SAE PAPER 871465] p 153 A88-21123

SPACE HABITATS
Crew factors in the design of the Space Station p 151 A88-10947
Power requirements for an orbiting space farm
[IAF PAPER 87-242] p 70 A88-15969
Providing artificial gravity - Physiologic limitations to rotating habitats
[IAF PAPER 87-545] p 152 A88-16163
Space Station habitat and laboratory module rack flight testing in the Spacehab Module
[SAE PAPER 871418] p 103 A88-21080
On-orbit servicing enhancements with Crewlock EVA operations from the Spacehab module
[SAE PAPER 871496] p 124 A88-21148
The Spacehab module passive thermal control
[SAE PAPER 871508] p 35 A88-21154
Design concepts for bioreactors in space p 45 N88-17179

SPACE INDUSTRIALIZATION
Industrial Space Facility
[AIAA PAPER 88-0649] p 3 A88-22484
Microgravity and Materials Processing Facility study (MMPF): Requirements and Analyses of Commercial Operations (RACO) preliminary data release
[NASA-CR-179309] p 104 N88-18742

SPACE LABORATORIES
Polymer crystal growth facility concept for Space Station laboratory module p 1 A88-15314
The Industrial Space Facility
[IAF PAPER 87-01] p 1 A88-15801
Telerobotics and orbital laboratories - An end-to-end analysis and demonstration
[IAF PAPER 87-27] p 83 A88-15819
A research laboratory in space
[IAF PAPER 87-60] p 161 A88-15840
Trends to reduce development and operation costs for experiments of the future space laboratory
[IAF PAPER 87-100] p 105 A88-15871
Space Station habitat and laboratory module rack flight testing in the Spacehab Module
[SAE PAPER 871418] p 103 A88-21080
Industrial Space Facility
[AIAA PAPER 88-0649] p 3 A88-22484
Preliminary study of a gravitational biology facility for Columbus, executive summary
[MATRA-EPT/AS/VT209/255/NT] p 145 N88-10205
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 2: Study results. Appendix E: Work breakdown structure and dictionary
[NASA-CR-179274] p 46 N88-17723
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 2: Study results. Appendix D: Life sciences research facility requirements
[NASA-CR-179275] p 46 N88-17724

SPACE LAW
The commercial use of space stations: The legal framework of trans-Atlantic cooperation; International Colloquium, Hanover, Federal Republic of Germany, June 12, 13, 1986, Reports
[DGLR BERICHT 86-02] p 160 A88-13443
The applicable legal regime for international cooperation on space stations p 133 A88-13446
A legal framework for Space Station activities p 160 A88-13447
The applicable legal regime for international cooperation p 160 A88-13448
Legal problems in the construction of space stations p 133 A88-13449
National jurisdiction on the Space Station p 160 A88-13450
Legal problems of the commercial use of space stations including proprietary rights p 160 A88-13452
Proprietary rights and commercial use of space stations p 161 A88-13453
The dangers of space debris - New developments and discoveries p 130 A88-18398
Colloquium on the Law of Outer Space, 28th, Stockholm, Sweden, Oct. 7-12, 1985, Proceedings p 164 A88-26187
Legal protection of the Polar Platform's users p 145 N88-12135

SPACE LOGISTICS
A model for evolving Space Station logistics requirements p 102 A88-15286
European Polar Platform operations and logistics
[IAF PAPER 87-15] p 135 A88-15812
Space Station supply, product return, and trash disposal
[IAF PAPER 87-219] p 123 A88-15949
Space Station logistic support by Aries
[IAF PAPER 87-222] p 137 A88-15950
The Resource Module p 140 A88-21559
Orbital Spacecraft Consumables Resupply System (OSCRS): Monopropellant application to space station and OMV automatic refueling impacts of an ELV launch, volume 4
[NASA-CR-172029] p 126 N88-11741
Inventory behavior at remote sites p 5 N88-14873

SPACE MAINTENANCE
Satellite servicing in the Space Station era p 121 A88-15288
MTFF operational design features p 134 A88-15296
Technology advancements for servicing of future spacecraft systems
[IAF PAPER 87-38] p 122 A88-15826
Stability analysis for alternative force control schemes as applied to remote space teleoperation
[AAS PAPER 87-043] p 81 A88-16998
Experiments in advanced control concepts for space robotics - An overview of the Stanford Aerospace Robotics Laboratory
[AAS PAPER 87-044] p 83 A88-16999
Use of communicating expert systems in fault diagnosis for Space Station applications p 43 A88-21635
Canada's Space Station Program p 142 A88-24980
Repair of Salyut 7 p 143 A88-25943
Damage detection and location in large space trusses
[AIAA PAPER 88-2481] p 18 A88-31384
Expert system study for spacecraft management
[TL-2699-ISS-1] p 101 N88-15004
SAMSS: An in-progress review of the Spacecraft Assembly, Maintenance, and Servicing Study p 127 N88-15930
Man-Tended Free Flyer operational design features p 128 N88-19485

SPACE MANUFACTURING
Medical aspects of orbital spaceflight and their implications for manufacturing in space p 39 A88-13182
The Industrial Space Facility
[IAF PAPER 87-01] p 1 A88-15801
An initial study of remotely manipulated stud welding for space applications p 86 A88-31274
Moving the factory into orbit p 165 N88-10844
Potential for on-orbit manufacture of large space structures using the pultrusion process
[NASA-TM-4016] p 29 N88-13388

SPACE MISSIONS
Rendezvous and docking technology for future European missions p 48 A88-15260
Spacecraft technology trends - A view from the past
[IAF PAPER 87-07] p 161 A88-15807

206

Economic benefits of the Space Station to commercial communication satellite operators
[IAF PAPER 87-622] p 183 A88-16215
PLAN-IT - Knowledge-based mission sequencing
p 7 A88-21644
Telescience testbedding for life science missions on the Space Station
[AIAA PAPER 88-0146] p 86 A88-22332
Radiation hazards on space missions
p 130 A88-22919
Critical issues for establishment of a permanently occupied lunar base
[AD-A187129] p 107 N88-17567
America plans for space
[AD-A187465] p 167 N88-17713
Rendezvous and docking verification and demonstration in orbit, executive summary
[MBB-303-16/86] p 61 N88-17719

SPACE OPERATIONS CENTER (NASA)
Environmental control and life support testing at the Marshall Space Flight Center
[SAE PAPER 871453] p 40 A88-21113

SPACE PLASMAS
Plasmoid tower station
[IAF PAPER 87-250] p 69 A88-15969
Alfven waves from an electrodynamic tethered satellite system
p 115 A88-25890

SPACE PLATFORMS
Power and resource management scheduling for scientific space platform applications
p 108 A88-11880
A Pallet-based space program for Australia
p 122 A88-15521
Thermal design of the equipment platforms
[IAF PAPER 87-06] p 34 A88-15806
GEO platform servicing - Technology solutions
[IAF PAPER 87-08] p 122 A88-15808
Environmental constraints for Polar Platform design
[IAF PAPER 87-09] p 108 A88-15809
Coorbitation of free-flyers
[IAF PAPER 87-14] p 108 A88-15811
EURECA - An expert system for the management of experiments to be performed on a free-flying platform
[IAF PAPER 87-29] p 135 A88-15821
The utilisation of the Columbus Polar Platform
[IAF PAPER 87-96] p 162 A88-15869
Operational utilization of the polar platforms
[IAF PAPER 87-116] p 109 A88-15882
Angular momentum management for LEO platforms
[IAF PAPER 87-349] p 49 A88-16039
Interim Flight Opportunity (IFO) — small European space experiment platform
[IAF PAPER 87-379] p 136 A88-16054
The DFS platform and its applications — German communication satellite
[IAF PAPER 87-470] p 138 A88-16119
Development of on-board satellite communications equipment in the Geostationary Platform era
[IAF PAPER 87-495] p 110 A88-16136
Explorer Platform — reusable spacecraft
[AIAA PAPER 88-0066] p 112 A88-22046
Tethers on stations and platforms
[AIAA PAPER 88-0534] p 113 A88-22399
Downward-deployed tethered platforms for high enthalpy aerothermodynamic research
[AIAA PAPER 88-0688] p 114 A88-22514
Man Tended Free Flyer configurations and servicing scenarios
[MBB-UR-E-984-87] p 125 A88-23990
The Spacebus platforms
[AIAA PAPER 88-0775] p 115 A88-27535
U.S. Space Platform firms aim for 1991 service start
p 164 A88-27954
A test-bed for space interferometry: Space Platform Interferometer (SPI)
p 5 N88-10840
Moving the factory into orbit p 165 N88-10844
Mission Peculiar Equipment Support Structure: A platform for space construction p 26 N88-10874
Estimating payload internal temperatures and radiator size for multimegawatt space platforms
[DE88-000244] p 37 N88-11738
Considerations concerning a thermal joint for a deployable or steerable battery radiator for the Columbus Polar Platform
[NLR-TR-86095-U] p 37 N88-11739
Commercial Opportunities for Remote Sensing with Polar Platforms
[ESA-SP-269] p 117 N88-12131
Possible commercial use of the polar platforms — Columbus
p 165 N88-12132
Payload configurations and serviceability — Columbus Polar Platforms
p 117 N88-12133
Legal protection of the Polar Platform's users
p 145 N88-12135
Confidentiality of data — Columbus Polar Platforms
p 145 N88-12136
X-band SAR for a European remote sensing payload
p 117 N88-12142
The effect of maximum allowable payload temperature on the mass of a multimegawatt space-based platform
[DE88-001821] p 37 N88-13381
Communications payload concepts for geostationary facilities
[NASA-TM-100154] p 76 N88-13513
Carbon Dioxide observational platform system (CO-OPS) Feasibility Study
[NASA-CR-179225] p 118 N88-14113
Feasibility study of a carbon dioxide observational platform system. Volume 2: Programmatics
[NASA-CR-180404] p 118 N88-14114
Polar platform element of Space Station: Mission objectives, European priorities, candidate instrumentation and selection procedure p 119 N88-16779
Model of space platform electromagnetic (EMC) configuration
[ESA-CR(P)-2500] p 9 N88-16809
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 1: Executive summary. Phase A: Conceptual design and programmatics
[NASA-CR-179268] p 104 N88-17721
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 2: Study results, attachment 2. Phase A: Conceptual design and programmatics
[NASA-CR-179272] p 46 N88-17722
Mobile robot activity model for autonomous free flying platforms p 92 N88-19507
Explorer Platform on-orbit servicing operations
p 121 N88-19526

SPACE POWER REACTORS
Coaxial tube array space transmission line characterization p 75 A88-11985
Space nuclear power systems 1986. Proceedings of the Third Symposium, Albuquerque, NM, Jan. 13-16, 1986
p 71 A88-22676
Space power needs and forecasted technologies for the 1990s and beyond p 71 A88-22677
Monolithic fuel cell based power source for burst power generation p 71 A88-22691

SPACE PROBES
Study of fault tolerant techniques for satellite data handling
[FTT/REP/0001/SAAB] p 101 N88-13860
Applications of expert systems for satellite autonomy
p 90 N88-16443

SPACE PROCESSING
Business issues of materials processing in space
p 160 A88-13451
USSR export possibilities in the field of space hardware
[SAE PAPER 871342] p 133 A88-14368
Polymer crystal growth facility concept for Space Station laboratory module p 1 A88-15314
One mission on board the MIR Space Station - The French-Soviet project Aragatz
[IAF PAPER 87-96] p 137 A88-15867
The protein crystallization facility (PCF) for Eureca
[IAF PAPER 87-412] p 110 A88-16082
Toward new materials processing in space
p 2 A88-21572
Vapor transport furnace for organic crystals and films
[AIAA PAPER 88-0180] p 113 A88-22113
Advanced protein crystal growth flight hardware for the Space Station
[AIAA PAPER 88-0345] p 3 A88-22253
Materials processing twin experiment
[AIAA PAPER 88-0348] p 183 A88-22255
Preliminary study of a containerless processing facility for Columbus, executive summary
[ESA-IT7-AO/1-1,834/85F] p 96 N88-10203
Prephase A study of a crystallization laboratory for Columbus, executive summary
[ESA-IT7-AO/1-1866/85F] p 96 N88-10206
Microgravity and Materials Processing Facility study (MMPF): Requirements and Analyses of Commercial Operations (RACO) preliminary data release
[NASA-CR-179309] p 104 N88-18742

SPACE PROGRAMS
Has manned space flight a future?
p 159 A88-10850
Looking to year 2001 p 104 A88-13874
Spacecraft technology trends - A view from the past
[IAF PAPER 87-07] p 161 A88-15807
Technology - The basis for the past, the key to the future
[IAF PAPER 87-47] p 161 A88-15833
The Columbus system aspects p 140 A88-21556
National Aeronautics and Space Administration space station proposal, fiscal year 1988
[S-HRG-100-326] p 166 N88-14043

SPACE PSYCHOLOGY
The role of psychologists in future spaceflight
p 159 A88-10958
Psychiatric components of a Health Maintenance Facility (HMF) on Space Station p 153 A88-20864

SPACE RENDEZVOUS
Simulation tools for the development of an autonomous rendezvous and docking system p 47 A88-13572
Rendezvous and docking technology for future European missions p 48 A88-15280
Orbit design for a space ambulance vehicle
p 149 A88-15313
Scanning laser radar system for rendezvous and docking in space
[IAF PAPER 87-53] p 48 A88-15838
Development of a cooperative operational rendezvous plan for Eureca and other maneuvering Shuttle payloads
[IAF PAPER 87-218] p 123 A88-15948
Control techniques for rendezvous and docking
p 51 A88-16311
Video-based satellite attitude determination
p 51 A88-21657
EPOS - A facility for simulating operations near spacecraft p 56 A88-32145
Rendezvous and Docking Verification (RVDV) and in-orbit demonstration, executive summary
[RVD-RVDV-FR-AS-01] p 127 N88-14120
Rendezvous and docking verification and demonstration in orbit, executive summary
[MBB-303-16/86] p 61 N88-17719
Motion simulation for in-orbit operations
p 62 N88-19514

SPACE SHUTTLE MISSION 41-C
In-orbit and laboratory exchange of ORUs designed/not designed for servicing p 151 N88-19499

SPACE SHUTTLE MISSION 61-B
A synopsis of the EVA training conducted on EASE/ACCESS for STS-61-B p 126 N88-10879
Overview of crew member energy expenditure during Shuttle Flight 61-B EASE/ACCESS task performance
p 156 N88-10882

SPACE SHUTTLE MISSIONS
Space Station assembly - Techniques and structures
p 104 A88-26420
Shuttle based assembly of Space station
[AIAA PAPER 88-2452] p 125 A88-31379
The 1987 Get Away Special Experimenter's Symposium
[NASA-CP-2500] p 121 N88-17691

SPACE SHUTTLE ORBITERS
Spacehab's commercialization of microgravity research activities
[IAF PAPER 87-629] p 110 A88-16221
Pinhole occulter experiment
[NASA-CR-179206] p 116 N88-11491

SPACE SHUTTLE PAYLOADS
Design, analysis, fabrication and test of the LARAR prototypeflight mirror assembly — Large Area Modular Array of Reflectors p 10 A88-12719
Development of a cooperative operational rendezvous plan for Eureca and other maneuvering Shuttle payloads
[IAF PAPER 87-218] p 123 A88-15948
Fault tolerant onboard implementation of control procedures in tethered satellite p 110 A88-16295
Results from a series of tethered rocket experiments
p 111 A88-19834
Recent developments in gravity gradiometry from the Space-Shuttle-borne tethered satellite system
p 112 A88-21531
Shuttle experiments to measure the optical environments surrounding large space structures
[AIAA PAPER 88-0432] p 14 A88-22321
Design and development of the truss assembly fixture for Space Station assembly operations
[AIAA PAPER 88-2455] p 18 A88-31380
Phase 3 study of erected tether applications in space. Volume 2: Study results
[NASA-CR-179186] p 116 N88-10828
Space Construction
[NASA-CP-2490] p 26 N88-10870
The flight demonstration program and selection process p 126 N88-10871
Mission Peculiar Equipment Support Structure: A platform for space construction p 26 N88-10874
Marshall Space Flight Center's role in EASE/ACCESS mission management p 27 N88-10875
A monograph of the National Space Transportation System Office (NSTSO) integration activities conducted at the NASA Lyndon B. Johnson Space Center for the EASE/ACCESS payload flown on STS 61-B
p 27 N88-10876
EASE/ACCESS ground processing at Kennedy Space Center p 27 N88-10877
Overview of crew member energy expenditure during Shuttle Flight 61-B EASE/ACCESS task performance
p 156 N88-10882

Potential for on-orbit manufacture of large space structures using the pultrusion process
[NASA-TM-4016] p 28 N88-13388
The dynamics and control of large flexible space structures, part 10
[NASA-CR-182426] p 29 N88-15830
Explorer Platform on-orbit servicing operations p 121 N88-19526
Research and technology, 1987
[NASA-TM-100323] p 167 N88-20253

SPACE SHUTTLE UPPER STAGES

Wimshooka X-ray detector and spacecraft design study p 108 A88-15511

SPACE SHUTTLES

Transitioning from Space Shuttle to Space Station on-orbit servicing p 121 A88-15290
Orbital Spacecraft Consumables Resupply System p 122 A88-15292
An overview of the Office of Space Flight satellite servicing program plan
[IAF PAPER 87-35] p 122 A88-15825
Soviet shuttle for Space Station role p 138 A88-19750
A conceptual design for a single-stage-to-orbit Space Station service vehicle
[AIAA PAPER 88-0089] p 3 A88-22063
Large space systems environmental entanglements
[AIAA PAPER 88-0388] p 14 A88-22286
From Space Shuttle to Space Station - Graduating from paper to electronic media
[AIAA PAPER 88-0442] p 183 A88-22329
A lunar laboratory p 156 A88-29196
Reusable space systems (Eugen Saenger Lecture, 1987) p 125 A88-32478
Fourteenth Space Simulation Conference: Testing for a Permanent Presence in Space
[NASA-CP-2446] p 5 N88-10829
Moving the factory into orbit p 165 N88-10844
Spacecraft material flammability testing and configurations p 96 N88-12129
Third Conference on Artificial Intelligence for Space Applications, part 1
[NASA-CP-2492-Pt-1] p 89 N88-16360
Telerobotic controller development p 89 N88-16370
Prototype resupply scheduler p 9 N88-16429

SPACE SIMULATORS

Space telerobotics technology demonstration program
[AAS PAPER 87-045] p 84 A88-17000
Structural Assembly Demonstration Experiment (SADE)
[NASA-CR-179205] p 26 N88-10868
Research and development at the Marshall Space Flight Center Neutral Buoyancy Simulator p 5 N88-10879

SPACE STATION PAYLOADS

Polymer crystal growth facility concept for Space Station laboratory module p 1 A88-15314
An overview of space station operations
[SAE SP-687] p 122 A88-15575
Telerobotics and orbital laboratories - An end-to-end analysis and demonstration
[IAF PAPER 87-27] p 83 A88-15819
Tethered space elevator - Possible applications and demonstrative experiments
[IAF PAPER 87-49] p 109 A88-15834
Space Station Information System - Concepts and international issues
[IAF PAPER 87-76] p 98 A88-15851
A packetized remote visual access data system for Space Station interactive payload operations p 99 A88-21253
An operations concept for the Space Station based Astrometric Telescope Facility
[AIAA PAPER 88-0447] p 113 A88-22333
A telescope for high energy gamma-ray measurements in the Space Station era
[AIAA PAPER 88-0852] p 114 A88-22485
Phase 3 study of selected tether applications in space. Volume 2: Study results
[NASA-CR-179186] p 116 N88-10828
Communications payload concepts for geostationary facilities
[NASA-TM-100154] p 76 N88-13513
Microgravity Particle Research on the Space Station
[NASA-CP-2496] p 119 N88-19354
Astrophysics and the solar nebula p 118 N88-15355
Planetary science p 5 N88-15356
Atmospheric science p 5 N88-15357
Exobiology and life science p 118 N88-15358
Physics and chemistry p 118 N88-15359
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 2: Study results. Appendix E: Work breakdown structure and dictionary
[NASA-CR-179274] p 46 N88-17723
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 2: Study results. Appendix D: Life sciences research facility requirements
[NASA-CR-179273] p 46 N88-17724
Progress toward a cosmic dust collection facility on space station
[NASA-CR-182427] p 121 N88-19566
Conceptual design and programmatics studies of space station accommodations for Life Sciences Research Facilities (LSRF)
[NASA-CR-179270] p 46 N88-19507
Space station accommodations for life sciences research facilities. Phase A conceptual design and programmatics studies for Missions SAAX0307, SAAX0302 and the transition from SAAX0307 to SAAX0302. Volume 1: Executive summary
[NASA-CR-179267] p 104 N88-19571
Analysis of low gravity tolerance of model experiments for space station. Preliminary results for directional solidification
[NASA-CR-183657] p 10 N88-19648
Research and technology, 1987
[NASA-TM-100323] p 167 N88-20253

SPACE STATION POLAR PLATFORMS

Columbus Space Segment definition p 133 A88-15293
European Polar Platform operations and logistics
[IAF PAPER 87-15] p 135 A88-15812
On-orbit servicing and cost effectiveness of Columbus polar platform concepts
[IAF PAPER 87-42] p 123 A88-15831
Configuration drivers for the European Polar Platform
[IAF PAPER 87-104] p 137 A88-15873
The Columbus polar platform p 140 A88-21558
A teleoperated manipulator system concept for unmanned platforms -- Columbus p 94 N88-19537

SPACE STATION POWER SUPPLIES

Space Station electric power system requirements and design p 63 A88-11782
Toluene stability Space Station Rankine power system p 63 A88-11794
Binary mercury/organic Rankine cycle power systems p 63 A88-11795
Advanced space solar dynamic power systems beyond IOC Space Station p 64 A88-11796
Solar concentrator advanced development project p 64 A88-11799
Reliability models for Space Station power system p 65 A88-11815
Computer modeling and simulation of a 20kHz ac distribution system for Space Station p 66 A88-11827
Allocating energy to experiments on the Space Station p 66 A88-11828
An integrated approach to space station power system autonomous control p 67 A88-11853
Applications for power control within a Space Station module p 67 A88-11854
Application of advanced automation techniques in the Space Station electrical power system p 75 A88-11855
Use of a distributed microprocessor network for control of the Space Station electrical power system p 67 A88-11856
A concept for standard load center automation p 67 A88-11857
Automated space power distribution and load management p 67 A88-11860
LERC power system autonomy program 1990 demonstration p 67 A88-11861
A systems engineering approach to automated failure cause diagnosis in space power systems p 68 A88-11870
Automated testing and integration of heterogeneous systems -- for Space Station power management p 33 A88-11874
Parametrics of nickel-hydrogen cell design -- for earth orbit vehicles p 75 A88-11912
Modeling the performance of the monogroove with screen heat pipe for use in the radiator of the solar dynamic power system of the NASA Space Station
[IAF PAPER 87-236] p 34 A88-15960
A free-flying power plant for a manned space station p 70 A88-16308
Development of composite facets for the surface of a space-based solar dynamic concentrator p 70 A88-18230
Electrical power for Columbus - An important cross-element task p 140 A88-21560
Cooperating expert systems for Space Station power distribution management p 71 A88-21633
The distributed AI system for the dynamic allocation and management of power (DAISY-DAMP) testbed p 84 A88-21638
Autonomous management of the Space Station electric energy system p 71 A88-21641
Structural assessment of a Space Station solar dynamic heat receiver thermal energy storage canister
[AIAA PAPER 88-2487] p 72 A88-31396
Space station assembly/servicing capabilities p 125 N88-10130
Solar converging method p 37 N88-12504
Space station systems: A bibliography with indexes
[NASA-SP-7056(05)] p 5 N88-13382

SPACE STATION PROPULSION

Space station propulsion technology: Space station propulsion system test bed test plan
[NASA-CR-179201] p 78 N88-1[illegible]4
Space station integrated propulsion and fluid system study: Fluid systems configuration databook
[NASA-CR-179215] p 79 N88-11753
Space station systems: A bibliography with indexes
[NASA-SP-7056(05)] p 5 N88-13382

SPACE STATION STRUCTURES

An overview of space station operations
[SAE SP-687] p 122 A88-15575
NASA and the Space Station - Current Status
[IAF PAPER 87-64] p 161 A88-15843
The Columbus space segment
[IAF PAPER 87-66] p 136 A88-15845
Assembling, maintaining and servicing Space Station
[IAF PAPER 87-85] p 123 A88-15859
The potential of Columbus element utilization
[IAF PAPER 87-94] p 137 A88-15865
Design of an ammonia two-phase Prototype Thermal Bus for Space Station
[SAE PAPER 871536] p 35 A88-21152
Columbus pressurized module p 140 A88-21557
Thermal contact conductance in the presence of thin metal foils
[AIAA PAPER 88-0468] p 35 A88-22342
Space erectable radiator system development
[AIAA PAPER 88-0469] p 36 A88-22345
Hypervelocity impact damage assessment for Space Station
[AIAA PAPER 88-2485] p 19 A88-31388
Development and properties of aluminum-clad graphite/epoxy tubes for space structures
[AIAA PAPER 88-2472] p 18 A88-31389
Response of composite materials to the Space Station orbit environment
[AIAA PAPER 88-2476] p 95 A88-31390
Space Station - A focus for the development of structural dynamics scale model technology for large flexible space structures
[AIAA PAPER 88-2483] p 19 A88-31392
Space station resistojet system requirements and interface definition study
[NASA-CR-180832] p 80 N88-12541
Advanced radiator concepts utilizing honeycomb panel heat pipes
[NASA-CR-172017] p 37 N88-12747
Space station systems: A bibliography with indexes
[NASA-SP-7056(05)] p 5 N88-13382
Personnel occupied woven envelope robot power
[NASA-CR-182367] p 98 N88-15196
Solar concentrator advanced development program, task 1
[NASA-CR-179489] p 74 N88-18068

SPACE STATIONS

Space Station viewing requirements
[SAE PAPER 861754] p 1 A88-10155
Preparing for the future -- NASA Space Station program p 153 A88-10368
Space Station careers past all obstacles p 159 A88-10367
Has manned space flight a future? p 156 A88-10850
Crew factors in the design of the Space Station p 151 A88-10947
Solar receiver for the Space Station Brayton engine
[ASME PAPER 87-GT-252] p 62 A88-11134
Capture-ejector satellites p 108 A88-11726
Space Station electric power system requirements and design p 63 A88-11782
Heat pipe radiators for solar dynamic space power system heat rejection p 33 A88-11807
Performance characteristics of a combination solar photovoltaic heat engine energy converter p 65 A88-11813
Control considerations for high frequency, resonant, power processing equipment used in large systems p 67 A88-11829
EMC and power quality standards for 20 kHz power distribution p 66 A88-11830
Coaxial tube array space transmission line characterization p 75 A88-11865
Autonomous spacecraft operations - Problems and solutions
[AIAA PAPER 87-2850] p 91 A88-12571
Fabrication and assembly of an advanced composite Space Station tetrahus cell p 11 A88-13189

The commercial use of space stations: The legal framework of trans-Atlantic cooperation; International Colloquium, Hanover, Federal Republic of Germany, June 12, 13, 1986, Reports
[DGLR BERICHT 86-02] p 160 A88-13443
Status of ongoing government-level negotiations on space stations p 132 A88-13444
Negotiating the Space Station p 160 A88-13445
The applicable legal regime for international cooperation on space stations p 133 A88-13446
A legal framework for Space Station activities p 160 A88-13447
The applicable legal regime for international cooperation p 160 A88-13448
Legal problems in the construction of space stations p 133 A88-13449
National jurisdiction on the Space Station p 160 A88-13450
Business issues of materials processing in space p 160 A88-13451
Legal problems of the commercial use of space stations including proprietary rights p 160 A88-13452
Proprietary rights and commercial use of space stations p 161 A88-13453
Disturbance and vibration isolation in space stations by means of mechanical decoupling p 11 A88-13932
On the hierarchical control of the Space Station common module thermal system p 33 A88-14980
Space Station ground data management system p 98 A88-15282
Technology advancements to improve crew productivity in space p 151 A88-15283
Design and development of a computer-assisted ground control technique for Space Station robotics p 62 A88-15284
CAMERA: Expert System for Space Station communications and tracking system management --- Control and Monitor Equipment Resource Allocation p 75 A88-15285
A model for developing Space Station logistics requirements p 102 A88-15286
Spacelab - A manned Space Station testbed p 150 A88-15287
Satellite servicing in the Space Station era p 124 A88-15288
The Canadian Mobile Servicing System for Space Station servicing p 87 A88-15289
Transitioning from Space Shuttle to Space Station on-orbit servicing p 124 A88-15290
OMV servicing mission from Space Station p 121 A88-15291
Orbital Spacecraft Consumables Resupply System p 122 A88-15292
Building intelligent systems - Artificial intelligence research at NASA Ames Research Center p 62 A88-15300
Orbit design for a space ambulance vehicle p 149 A88-15313
Small groups in orbit - Group interaction and crew performance on Space Station p 161 A88-15348
Optimization of the energy systems of manned orbital stations - Mathematical modeling and selection of efficient structures --- Russian book p 98 A88-15864
The Industrial Space Facility
[IAF PAPER 87-01] p 1 A88-15801
International Space Station operations: New dimensions - October 13, 1987
[IAF PAPER 87-13] p 122 A88-15810
Coorbitation of free flyers
[IAF PAPER 87-14] p 108 A88-15811
Geostationary earth observations - Platform operations from the Space Station
[IAF PAPER 87-19] p 108 A88-15814
The Flight Telerobotic Servicer (FTS) - A focus for automation and robotics on the Space Station
[IAF PAPER 87-25] p 62 A88-15817
Applicability of A.I. techniques to the Space Station, a study case - Development of an expert system for on board fault management
[IAF PAPER 87-30] p 93 A88-15822
A new Italian proposal for a Space Station Assembly and Servicing Vehicle (ASMV)
[IAF PAPER 87-37] p 135 A88-15827
Tethered space elevator - Possible applications and demonstrative experiments
[IAF PAPER 87-49] p 109 A88-15834
A research laboratory in space
[IAF PAPER 87-60] p 161 A88-15840
JEM present project status --- Japan Experiment Module
[IAF PAPER 87-63] p 135 A88-15842
NASA and the Space Station - Current Status
[IAF PAPER 87-64] p 161 A88-15843
United States Space Station technical and programmatic interfaces
[IAF PAPER 87-65] p 162 A88-15844
Evolution towards an autonomous European manned space infrastructure
[IAF PAPER 87-67] p 136 A88-15846
Possibilities for a European evolutionary space infrastructure
[IAF PAPER 87-68] p 105 A88-15847
The impact of launch vehicle constraints on U.S. Space Station design and operations
[IAF PAPER 87-72] p 2 A88-15848
Automation and robotics technology application to JEM --- Japanese Experiment Module
[IAF PAPER 87-74] p 136 A88-15849
Long-term evolution toward European manned spaceflight
[IAF PAPER 87-78] p 136 A88-15853
Selected advanced technology studies for the U.S. Space Station --- waste water reclamation, module design and fabrication
[IAF PAPER 87-79] p 2 A88-15854
The United States Space Station revised baseline
[IAF PAPER 87-81] p 162 A88-15855
Space Station Program implications from the viewpoint of the Space Station Operations Task Force
[IAF PAPER 87-82] p 123 A88-15856
The beginning of the Mir station active operation
[IAF PAPER 87-84] p 136 A88-15858
Science on the Space Station: The opportunity and the challenge - A NASA view
[IAF PAPER 87-92] p 96 A88-15863
Science plans and requirements for the U.S./International Space Station
[IAF PAPER 87-93] p 103 A88-15864
Space Station accommodation of attached payloads
[IAF PAPER 87-97] p 103 A88-15868
Space Station services and design features for users
[IAF PAPER 87-99] p 103 A88-15870
Evolutionary Space Station infrastructure
[IAF PAPER 87-103] p 105 A88-15872
Problem of control arisen during the implementation of scientific research program onboard the multipurpose orbital stations
[IAF PAPER 87-105] p 48 A88-15874
Development scenario of H-II Orbiting Plane, HOPE
[IAF PAPER 87-210] p 48 A88-15943
Space Station supply, product return, and trash disposal
[IAF PAPER 87-219] p 123 A88-15949
Space Station logistic support by Ariane
[IAF PAPER 87-222] p 137 A88-15950
Optical measurements pertaining to Space Station solar dynamic power systems
[IAF PAPER 87-229] p 60 A88-15954
Space Station Electrical Power System
[IAF PAPER 87-234] p 60 A88-15958
Aspects and possibilities of an integrated energy and media supply system on H2/O2 basis for manned space stations in the low earth orbit
[IAF PAPER 87-241] p 38 A88-15963
Water-propellant resistojets for man-tended platforms
[IAF PAPER 87-259] p 78 A88-15975
The passive attitude motion of the orbital stations Salyut-6 and Salyut-7
[IAF PAPER 87-355] p 49 A88-16045
Acceleration measurement and management on a space station
[IAF PAPER 87-364] p 50 A88-16049
Microgravity research and user support in the Space Station era - The Microgravity User Support Center
[IAF PAPER 87-390] p 110 A88-16061
A conceptual design for a single-stage-to-orbit Space Station Service Vehicle
[IAF PAPER 87-(07-07)] p 2 A88-16071
Manned Mars mission accomodation by the evolutionary Space Station
[IAF PAPER 87-438] p 105 A88-16097
Radiation problems with the Space Station scenario and the necessary surveillance for astronauts
[IAF PAPER 87-542] p 129 A88-16160
Human factor design of habitable space facilities
[IAF PAPER 87-549] p 38 A88-16166
Low-cost prototypes for human factors evaluation of Space Station crew equipment
[IAF PAPER 87-553] p 152 A88-16170
Economic benefits of the Space Station to commercial communication satellite operators
[IAF PAPER 87-622] p 163 A88-16215
Station pricing - Not just a question of 'How much does it cost?'
[IAF PAPER 87-631] p 163 A88-16223
Design-to-performance --- of controllers for Space Stations p 2 A88-16295
Earth science missions for the Space Station p 111 A88-17039
Robots - Autonomous space workers p 84 A88-19868
Earth observation from the Space Station p 112 A88-20067
The opportunities for space biology research on the Space Station p 153 A88-20282
Assembling the Space Station p 123 A88-20475
AUTOPLAN - A PC-based automated mission planning tool p 7 A88-20486
A dishwasher for the Space Station
[SAE PAPER 871411] p 38 A88-21076
Accommodating life sciences on the Space Station
[SAE PAPER 871412] p 38 A88-21077
OSSA Space Station waste inventory
[SAE PAPER 871413] p 39 A88-21078
FACILE - A computer program for Space Station facilities layout and activity simulation
[SAE PAPER 871415] p 7 A88-21079
Space Station habitat and laboratory module rack flight testing in the Spacehab Module
[SAE PAPER 871416] p 103 A88-21080
Environmental control and life support systems analysis for a Space Station life sciences animal experiment
[SAE PAPER 871417] p 39 A88-21081
A computer aided engineering tool for ECLS systems
[SAE PAPER 871423] p 98 A88-21087
Simulation and control of a Space Station air revitalization system
[SAE PAPER 871425] p 7 A88-21089
G189 computer program: modeling of environmental control and life support systems for the Space Station
[SAE PAPER 871427] p 39 A88-21090
Intermodule ventilation studies for the Space Station
[SAE PAPER 871428] p 130 A88-21091
Recent developments in water quality monitoring for Space Station reclaimed wastewaters
[SAE PAPER 871447] p 40 A88-21107
The Space Station air revitalization subsystem design concept
[SAE PAPER 871448] p 40 A88-21108
Static feed electrolyzer technology advancement for space application
[SAE PAPER 871450] p 40 A88-21110
Performance evaluation of SPE electrolyzer for Space Station life support
[SAE PAPER 871451] p 40 A88-21111
Stability of IRA-45 solid amine resin as a function of carbon dioxide absorption and steam desorption cycling
[SAE PAPER 871452] p 40 A88-21112
Initial results of integrated testing of a regenerative ECLSS at MSFC
[SAE PAPER 871454] p 41 A88-21114
Technology demonstrator program for Space Station Environmental Control Life Support System
[SAE PAPER 871456] p 41 A88-21115
Biorotation on the Space Station - Of mice and men
[SAE PAPER 871457] p 153 A88-21116
Life sciences biomedical research planning for Space Station
[SAE PAPER 871464] p 153 A88-21122
Biotechnology opportunities on Space Station
[SAE PAPER 871468] p 154 A88-21124
Water management requirements for animal and plant maintenance on the Space Station
[SAE PAPER 871469] p 41 A88-21125
Development of a regenerable humidity and CO2 control system for an advanced EMU
[SAE PAPER 871471] p 41 A88-21127
High pressure water electrolysis for the Space Station
[SAE PAPER 871473] p 41 A88-21128
Assessment of external contamination for Space Station scientific payloads
[SAE PAPER 871476] p 130 A88-21131
Treatment bed microbiological control
[SAE PAPER 871492] p 42 A88-21146
Preliminary design of the Space Station internal thermal control system
[SAE PAPER 871505] p 35 A88-21151
Space Station body mounted radiator design
[SAE PAPER 871507] p 35 A88-21153
Development of a non-phase-change waste-water treatment subsystem
[SAE PAPER 871514] p 43 A88-21159
Experimental study for carbon dioxide removal system in Space Station
[SAE PAPER 871516] p 43 A88-21161
An experimental study of the Bosch and the Sabatier CO2 reduction processes
[SAE PAPER 871517] p 43 A88-21162
Space Station propulsion system technology p 79 A88-21255
Principles of operations cooperation between the United States and Europe p 141 A88-21584
Science on Space Station p 2 A88-21586
Scientific objectives and functional requirements of life sciences in the Space Station p 154 A88-21570
International cooperation in the Space Station p 142 A88-21573

Japan's contribution to the Space Station program
p 142 A88-21574
Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 29-30, 1986
[SPIE-729] p 84 A88-21631
Use of automation and robotics for the Space Station
p 84 A88-21632
Controlling real-time processes on the Space Station with expert systems p 84 A88-21634
Use of communicating expert systems in fault diagnosis for Space Station applications p 43 A88-21635
Automatic planning research applied to orbital construction p 124 A88-21637
NASA Systems Autonomy Demonstration Program - A step toward Space Station automation
p 84 A88-21639
An approach to design knowledge capture for the space station p 7 A88-21642
Translation and execution of distributed Ada programs - Is it still Ada? p 7 A88-21643
Implementation of expert system technology on the Space Station p 99 A88-21654
Impact of intelligent systems on Space Station man-machine interface (MMI) design p 85 A88-21655
Focus of attention in systems for visual monitoring of experiments p 112 A88-21656
A conceptual design for a single-stage-to-orbit Space Station service vehicle
[AIAA PAPER 88-0089] p 3 A88-22063
Network management for the Space Station Information System
[AIAA PAPER 88-0119] p 99 A88-22082
OSSA's Telescience concept for the Space Station era
[AIAA PAPER 88-0130] p 112 A88-22083
Advanced protein crystal growth flight hardware for the Space Station
[AIAA PAPER 88-0345] p 3 A88-22253
Efficient spacecraft formation-keeping with consideration of ballistic coefficient control
[AIAA PAPER 88-0375] p 124 A88-22277
From Space Shuttle to Space Station - Graduating from paper to electronic media
[AIAA PAPER 88-0442] p 163 A88-22329
Automated Space Station procedure execution
[AIAA PAPER 88-0443] p 99 A88-22329
Onboard training for the Space Station
[AIAA PAPER 88-0445] p 154 A88-22331
Space Station Active Thermal Control System modeling
[AIAA PAPER 88-0473] p 36 A88-22349
Tethers on stations and platforms
[AIAA PAPER 88-0534] p 113 A88-22389
Space Station attitude control momentum requirements
[AIAA PAPER 88-0672] p 51 A88-22502
A relatively general formulation for studying dynamics of the Space Station based MRMS with applications -- Mobile Remote Manipulator System
[AIAA PAPER 88-0674] p 52 A88-22504
Intelligent systems and robotics for an evolutionary Space Station p 86 A88-24239
Canada's Space Station Program p 142 A88-24380
New radiator system designed for large spacecraft
p 36 A88-21368
Space Station Program threat and vulnerability analysis
[AIAA PAPER 87-3082] p 104 A88-26210
Access control for a safety critical distributed system interface set
[AIAA PAPER 87-3083] p 100 A88-26211
Space Station assembly - Techniques and structures
p 104 A88-26420
Development of a master slave manipulator system for space use p 86 A88-26975
Information prioritization for control and automation of space operations p 86 A88-27305
In-space research, technology and engineering experiments and Space Station p 3 A88-27750
Momentum management and attitude control design for a Space Station p 55 A88-26253
The opportunities for space biology research on the Space Station p 155 A88-29134
The feasibility of Chlorella as the exchanger of CO2 for O2 and the food resources in the Space Station
p 43 A88-29136
Need, utilization, and configuration of a large, multi-G centrifuge on the Space Station p 155 A88-29140
A lunar laboratory p 106 A88-29198
Simple analysis of Space Station downlinks
p 100 A88-30189
AIAA SDM issues of the international Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers p 17 A88-31376
Structures and materials technology for Space Station
[AIAA PAPER 88-2448] p 17 A88-31377
Shuttle based assembly of Space Station
[AIAA PAPER 88-2452] p 125 A88-31379
Design and development of the truss assembly fixture for Space Station assembly operations
[AIAA PAPER 88-2455] p 18 A88-31380
EVA construction and repair of tubular systems on Space Station
[AIAA PAPER 88-2456] p 125 A88-31381
Astronaut/EVA construction of Space Station
[AIAA PAPER 88-2459] p 125 A88-31382
Nondestructive construction error detection in large space structures
[AIAA PAPER 88-2460] p 18 A88-31383
Steady state micro-g environment on Space Station
[AIAA PAPER 88-2462] p 4 A88-31385
Space Station probability of no penetration due to meteoroid and orbital debris impact
[AIAA PAPER 88-2464] p 19 A88-31387
Dynamics and control characteristics of a reference Space Station configuration
[AIAA PAPER 88-2465] p 55 A88-31394
The impact of asymmetric physical properties on large space structures
[AIAA PAPER 88-2466] p 19 A88-31395
Space Station pressure wall repair techniques
[AIAA PAPER 88-2469] p 19 A88-31397
Long-life assurance for Space Station - Is it an issue?
[AIAA PAPER 88-2469] p 43 A88-31398
Orbit lifetime characteristics for Space Station
[AIAA PAPER 88-2490] p 55 A88-31399
Aerothermodynamics: A key to new aerospace transport systems
[DGLR PAPER 87-077] p 4 A88-32477
Space Station Mission Planning System (MPS) development study Volume 1 Executive summary
[NASA-CR-179202] p 4 N88-10047
Space Station Mission Planning System (MPS) development study Volume 2
[NASA-CR-179230] p 4 N88-10048
Space Station Mission Planning Study (MPS) development study Volume 3 Software development plan
[NASA-CR-179203] p 4 N88-10049
Space station integrated wall design and penetration damage control
[NASA-CR-179169] p 25 N88-10070
Space station: Leadership for the future
[NASA-PAM-509-8-87] p 165 N88-10072
Study of a payload for Columbus Polar Platform Earth observation demonstration mission, executive summary
[ESA-CR(P)-2412] p 116 N88-10079
Columbus preparatory program: Payload element study on a technology demonstration mission, executive summary
[CS-RP-AI-016] p 145 N88-10080
Spacecraft 2000
[NASA-CP-2473] p 106 N88-10084
Space station platforms p 116 N88-10086
Space station assembly servicing capabilities
p 125 N88-10100
Efficient placement of structural dynamics sensors on the space station
[NASA-CR-172015] p 25 N88-10103
Preliminary study of a containerless processing facility for Columbus, executive summary
[ESA-ITT-AO/1-1.634/85F] p 96 N88-10203
Prephase A study of a crystallization laboratory for Columbus, executive summary
[ESA-ITT/AO/1-1666/85F] p 96 N88-10206
Study of mobile communications payload for Columbus Polar Platforms
[ITS-TR-056A/86] p 76 N88-10220
Catalytic processes for space station waste conversion
[NASA-CR-177423] p 44 N88-10491
Space station based interferometry
p 116 N88-10629
Solar-terrestrial research in the space station era
p 116 N88-10747
Fourteenth Space Simulation Conference: Testing for a Permanent Presence in Space
[NASA-CP-2446] p 5 N88-10829
Columbus pressurized module verification
p 145 N88-10842
Moving the factory into orbit p 165 N88-10844
Rapid toxicity detection in water quality control utilizing automated multispecies biomonitoring for permanent space stations p 44 N88-10848
Space station contamination considerations
p 131 N88-10859
Contamination control concepts for space station customer servicing p 131 N88-10860
Predictive momentum management for a space station measurement and computation requirements
[NASA-CR-172026] p 58 N88-10868
Space Construction
[NASA-CP-2480] p 26 N88-10870
Space station: National Aeronautics and Space Administration's 1987 cost estimate
[PB87-220760] p 165 N88-10883
Particle cucutter experiment
[NASA-CR-179206] p 116 N88-11481
Orbital Spacecraft Consumables Resupply System (OSCRS): Volume 4: Extended study results
[NASA-CR-172012] p 126 N88-11586
Orbital Spacecraft Consumables Resupply System (OSCRS): Monopropellant application to space station and OMV automatic refueling impacts of an ELV launch, volume 4
[NASA-CR-172029] p 126 N88-11741
Photovoltaic power modules for NASA's manned space station
[NASA-TM-100229] p 72 N88-11745
Space station propulsion
[NASA-TM-100216] p 79 N88-11746
Space station integrated propulsion and fluid system study: Fluid systems configuration database
[NASA-CR-179215] p 79 N88-11753
An allotment planning concept and related computer software for planning the fixed satellite service at the 1988 space WARC
[NASA-TM-100244] p 165 N88-11944
Potential applications of expert systems and operations research to space station logistics functions
[NASA-CR-180473] p 87 N88-12042
Department of Housing and Urban Development-Independent Agencies Appropriations for fiscal year 1988, Thursday, 9 April 1987: National Aeronautics and Space Administration
p 166 N88-12424
Department of Housing and Urban Development-Independent Agencies Appropriations for fiscal year 1988, Friday, 10 April 1987: National Aeronautics and Space Administration
p 166 N88-12425
Spacecraft Fire Safety
[NASA-CP-2476] p 156 N88-12520
Space station internal environmental and safety concerns p 156 N88-12527
Optimization techniques applied to passive measures for in-orbit spacecraft survivability
[NASA-CR-179216] p 5 N88-12532
An assessment of clinical chemical sensing technology for potential use in space station health maintenance facility
[NASA-CR-172013] p 156 N88-12526
Space suit extravehicular hazards protection development
[NASA-TM-100458] p 157 N88-12527
Orbital Spacecraft Consumables Resupply System (OSCRS): Volume 1: Executive summary
[NASA-CR-172010] p 126 N88-13368
Design and assembly sequence analysis of option 3 for CETF reference space station
[NASA-TM-100503] p 126 N88-13369
Space station systems: A bibliography with indexes
[NASA-SP-7056(05)] p 5 N88-13387
Feasibility study for gas-grain simulation facility
[NASA-CR-177468] p 28 N88-13954
National Aeronautics and Space Administration space station proposal, fiscal year 1988
[S-HRG-100-328] p 166 N88-14043
The 1988 NASA (National Aeronautics and Space Administration) authorization
[GPO-80-245] p 166 N88-14044
Approaches and possible improvements in the area of multibody dynamics modeling
[NASA-CR-179227] p 28 N88-14067
Controlled Ecological Life Support Systems (CELSS) conceptual design option study
[NASA-CR-177421] p 44 N88-14625
Controlled Ecological Life Support Systems (CELSS) physiochemical waste management systems evaluation
[NASA-CR-177422] p 45 N88-14626
National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987, Volume 2
[NASA-CR-172009-VOL-2] p 166 N88-14874
Performance considerations for the astrometric telescope facility on the phase 1 space station
[NASA-TM-100040] p 45 N88-14898
Space station accommodations for lunar base elements: A study
[NASA-TM-100501] p 106 N88-14907
A space transportation system operations model
[NASA-TM-100481] p 8 N88-14999
Space station onboard propulsion system: Technology study
[NASA-CR-179233] p 80 N88-15006

Chromic acid anodizing of aluminum foil
[NASA-CR-179417] p 97 N88-15077
Space environmental effects on polymeric materials
[NASA-CR-182418] p 97 N88-15082
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems
[NASA-TM-89705] p 98 N88-15497
Some considerations on measuring the Newtonian gravitational constant G in an orbiting laboratory
p 119 N88-15603
The feasibility of using TAE as the UIL for the space station and for other internal NASA tasks and projects
p 9 N88-15618
Can space station software be specified through Ada?
p 9 N88-15622
Advancing automation and robotics technology for the space station and for the US economy. Submitted to the United States Congress October 1, 1987
[NASA-TM-100777] p 98 N88-15816
Advancing automation and robotics technology for the space station and for the US economy. Submitted to the United States Congress May 15, 1987
[NASA-TM-89811] p 98 N88-15817
Advancing automation and robotics technology for the space station and for the US economy. Submitted to the United States Congress October 1, 1986
[NASA-TM-89190] p 99 N88-15818
Development of an emulation-simulation thermal control model for space station application
[NASA-CR-182429] p 97 N88-15823
Space station accommodations for life sciences research facilities. Phase 1: Conceptual design and programmatics studies for Missions SAAK0307, SAAK0302 and the transition from SAAK0307 to SAAK0302. Volume 2: Study results
[NASA-CR-179264] p 104 N88-15829
Space station propulsion technology
[NASA-CR-179260] p 80 N88-15835
Status of 20 kHz space station power distribution technology
[NASA-TM-100791] p 73 N88-15838
Third Conference on Artificial Intelligence for Space Applications, part 1
[NASA-CP-2492-Pt-1] p 89 N88-16360
Telerobotic controller development p 89 N88-16370
MTK: An AI tool for model-based reasoning
p 9 N88-16372
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems
p 89 N88-16373
KBS V and V as related to automation of space station subsystems. Rationale for a KBS lifecycle
p 9 N88-16375
Monitoring of space station life support systems with miniature mass spectrometry and artificial intelligence
p 45 N88-16376
Artificial intelligence and space power systems automation p 89 N88-16381
Goal driven kinematic simulation of flexible arm robot for space station missions p 89 N88-16388
FMEAssist: A knowledge-based approach to Failure Modes and Effects Analysis p 101 N88-16395
Solid modeling for the manipulative robot arm (power) and adaptive vision control for space station missions
p 89 N88-16409
Planning and scheduling for robotic assembly
p 90 N88-16416
Planning activities in space p 9 N88-16417
Intelligent man/machine interfaces on the space station p 90 N88-16418
An AI approach for scheduling space-station payloads at Kennedy Space Center p 90 N88-16425
The resource envelope as a basis for space station management system scheduling p 152 N88-16427
Prototype resupply scheduler p 9 N88-16428
Prototype space station automation system delivered and demonstrated at NASA p 45 N88-16442
Applications of expert systems for satellite autonomy
p 90 N88-16443
Space station structures development
[NASA-CR-179261] p 30 N88-16782
Communications satellite systems operations with the space station. Volume 3: Supplementary technical report
[NASA-CR-180875] p 77 N88-16784
Development of a coupled expert system for the spacecraft attitude control problem p 61 N88-17223
Design knowledge capture for the space station
p 9 N88-17239
Vision technology/algorithms for space robotics applications p 90 N88-17267
Manipulator arm design for the Extravehicular Teleoperator Assist Robot (ETAR): Applications on the space station p 91 N88-17270
Telerobot for space station p 91 N88-17274
Space station integrated wall damage and penetration damage control. Task 5: Sparo debris measurement, mapping and characterization system
[NASA-CR-179281] p 30 N88-17688
The 1987 Get Away Special Experimenter's Symposium
[NASA-CP-2500] p 121 X88-17691
Simulation test beds for the space station electrical power system
[NASA-TM-100795] p 74 N88-17715
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 1: Executive summary. Phase A: Conceptual design and programmatics
[NASA-CR-179268] p 104 N88-17721
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 2: Study results, attachment 2. Phase A: Conceptual design and programmatics
[NASA-CR-179272] p 46 N88-17722
Report of the Committee on the Space Station of the National Research Council
[NASA-CR-181602] p 167 N88-17727
Magnetic emissions testing of the space station engineering model resistojet
[NASA-TM-100798] p 91 N88-17729
Component data base for space station resistojet auxiliary propulsion
[NASA-CR-180834] p 91 N88-17731
NASA/NBS (National Aeronautics and Space Administration/National Bureau of Standards) standard reference model for Telerobot Control System Architecture (NASREM)
[PB88-124773] p 92 N88-17999
Assessment of mixed fleet potential for space station launch and assembly
[NASA-TM-100550] p 107 N88-18608
Orbital transfer vehicle concept definition and system analysis study. Volume 4: Space station accommodations. Revision 1
[NASA-CR-179293] p 150 N88-18609
Orbital transfer vehicle concept definition and system analysis study. Volume 4, Appendix A: Space station accommodations. Revision 1
[NASA-CR-179294] p 150 N88-18610
Space station operating system study
[NASA-CR-179308] p 127 N88-18619
Microgravity and Materials Processing Facility study (MMPF): Requirements and Analyses of Commercial Operations (RACO): preliminary data release
[NASA-CR-179309] p 104 N88-18742
Computer-aided modeling and prediction of performance of the modified Lundell class of alternators in space station solar dynamic power systems
[NASA-CR-182539] p 74 N88-19000
Space vehicle approach velocity judgments under simulated visual space conditions
[NASA-TM-89437] p 158 N88-19094
Study of industry requirements that can be fulfilled by combustion experimentation aboard space station
[NASA-CR-180854] p 167 N88-19377
A lunar transportation system
[NASA-CR-182561] p 107 N88-19379
Preliminary analysis of an integrated logistics system for OSSA payloads
[NASA-CR-4114] p 6 N88-19477
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 1: Executive summary
p 6 N88-19478
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 2: OSSA integrated logistics support strategy p 6 N88-19479
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 3: OSSA integrated logistics support planning document p 6 N88-19480
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 4: Supportability analysis of the 1.8m centrifuge p 6 N88-19481
State-of-the-art technologies for construction in space: A review
[AD-A188412] p 31 N88-19483
Proceedings of the 1st European In-Orbit Operations Technology Symposium
[ESA-SP-272] p 129 N88-19484
Safe rendezvous approach to a space station by impulsive transfers and continuous thrust arcs
p 151 [illegible]
Assembly and servicing of a European [illegible]
p 1[illegible] N88-19492
Utilization of SMS and EVA for the [illegible] European Space Station [illegible] p 19500
Robotic intelligence issues [illegible] manipulator monitoring, control programming [illegible] N88-19504
Technology requirements for [illegible] robotic satellite servicing in space p 93 N88-19536
Analysis of a rotating advanced-technology space station for the year 2025
[NASA-CR-178045] p 107 N88-19580
Space station architectural elements model study. Space station human factors research review
p 102 N88-19884
Space station architectural elements model study
[REPT-31799] p 10 N88-19885
Space station group activities habitability module study: A synopsis p 6 N88-19886
Full scale architectural simulation techniques for space stations p 10 N88-19887
Social factors in space station interiors
p 46 N88-19888

SPACE SUITS

European EVA requirements and space suit design
[IAF PAPER 87-41] p 152 A88-15230
Crewman rescue equipment in manned space missions - Aspects of application
[IAF PAPER 87-576] p 153 A88-16187
EVA for a European Scenario
[SAE PAPER 871432] p 123 A88-21095
Development of a thermal control coating for space suits
[SAE PAPER 871474] p 34 A88-21129
Evolutive concept of an EVA space suit
[SAE PAPER 871518] p 154 A88-21163
Off to see the wizard — space suits
p 164 A88-22957
NASA to evaluate two suit designs for Space Station
p 155 A88-24101
Space suit extravehicular hazards protection development
[NASA-TM-100458] p 157 N88-12927
EVA, the technological challenge p 128 N88-19535

SPACE TECHNOLOGY EXPERIMENTS

Future in-orbit technology demonstrations
p 14 A88-21521

SPACE TEMPERATURE

Outgassing of spacecraft composites
p 95 A88-31404

SPACE TOOLS

New tools for EVA operations
[SAE PAPER 871489] p 124 A88-21150

SPACE TRANSPORTATION

Logistics flow for Columbus MTFF
[IAF PAPER 87-39] p 123 A88-15829
Costs and benefits of future heavy Space Freighters
[IAF PAPER 87-617] p 163 A88-16211
Small reentry vehicles p 150 A88-26364

SPACE TRANSPORTATION SYSTEM

ENVIRONET database on vibroacoustics
[AIAA PAPER 88-0010A] p 99 A88-22011
A 50 year scenario for the utilization of space to improve the quality of life on earth p 164 A88-27858
Space Construction
[NASA-CP-2480] p 26 N88-10870
The flight demonstration program and selection process p 126 N88-10871
A monograph of the National Space Transportation System Office (NSTSO) integration activities conducted at the NASA Lyndon B. Johnson Space Center for the EASE/ACCESS payload flown on STS 61-B
p 27 N88-10876
Pinhole occulter experiment
[NASA-CR-179206] p 116 N88-11481
Department of Housing and Urban Development-Independent Agencies Appropriations for fiscal year 1988. Friday, 10 April 1987: National Aeronautics and Space Administration
p 166 N88-12425
A space transportation system operations model
[NASA-TM-100481] p 8 N88-14999
STS propellant scavenging systems study. Part 2, volume 2: Cost and WBS/dictionary
[NASA-CR-179276] p 91 N88-17717
A two stage launch vehicle for use as an advanced space transportation system for logistics support of the space station
[NASA-CR-182572] p 107 N88-18606
Assessment of mixed fleet potential for space station launch and assembly
[NASA-TM-100550] p 107 N88-18608
Research and technology, 1987
[NASA-TM-100323] p 167 N88-20253

SPACE VEHICLE CHECKOUT PROGRAM

RETL experiment Assembly, Integration, and Verification (AIV) activities
[IFSI-87-6] p 117 N88-13380

SPACE WEAPONS

Monolithic fuel cell based power source for burst power generation p 71 A88-22691

SPACEBORNE ASTRONOMY

The high-flying Kvant module p 139 A88-20457

211

An operations concept for the Space Station based Astrometric Telescope Facility
[AIAA PAPER 88-0447] p 113 A88-22333
ISIS: Imaging Speckle Interferometer in Space
p 116 N88-10625
Space station based interferometry
p 116 N88-10626
A test-bed for space interferometry: Space Platform Interferometer (SPI) p 5 N88-10640
Use of Space Station for space science
p 120 N88-16762
Microgravity payloads and missions for Space Station: Some issues affecting compatibility with other payloads
p 120 N88-16763

SPACEBORNE EXPERIMENTS
Allocating energy to experiments on the Space Station
p 66 A88-11826
A Pallet-based space program for Australia
p 122 A88-15521
Results of medical investigations conducted aboard the 'Salyut-6'-'Soyuz' orbital research complex — Russian book
p 135 A88-15850
The in-orbit technology demonstration programme of the European Space Agency
[IAF PAPER 87-03] p 135 A88-15803
EURECA - An expert system for the management of experiments to be performed on a free-flying platform
[IAF PAPER 87-29] p 135 A88-15821
Science plans and requirements for the U.S./International Space Station
[IAF PAPER 87-93] p 103 A88-15864
Problem of control arisen during the implementation of scientific research program onboard the multipurpose orbital stations
[IAF PAPER 87-105] p 48 A88-15874
Interim Flight Opportunity (IFO) — small European space experiment platform
[IAF PAPER 87-379] p 139 A88-16054
Microgravity research and user support in the Space Station era - The Microgravity User Support Center
[IAF PAPER 87-390] p 110 A88-16061
Biomedical payload of the French-Soviet long duration flight
[IAF PAPER 87-541] p 152 A88-16159
Support of life science research in space by the DFVLR Microgravity User Support Center (MUSC)
[IAF PAPER 87-544] p 152 A88-16162
Space biologist's inflight safety considerations
[IAF PAPER 87-570] p 153 A88-16182
Spacehab's commercialization of microgravity research activities
[IAF PAPER 87-629] p 110 A88-16221
Tethered space system - A new facility for experimental rarefied gas dynamics p 111 A88-16858
Results from a series of tethered rocket experiments
p 111 A88-19834
The opportunities for space biology research on the Space Station p 153 A88-20282
Accommodating life sciences on the Space Station
[SAE PAPER 871412] p 38 A88-21077
Environmental control and life support systems analysis for a Space Station life sciences animal experiment
[SAE PAPER 871417] p 39 A88-21081
Life sciences biomedical research planning for Space Station
[SAE PAPER 871464] p 153 A88-21122
Water management requirements for animal and plant maintenance on the Space Station
[SAE PAPER 871469] p 41 A88-21125
Inflight microbial analysis technology
[SAE PAPER 871493] p 42 A88-21147
Future in-orbit technology demonstrations
p 14 A88-21521
Science on Space Station p 2 A88-21566
Prospects and problems in microgravity fluid science
p 2 A88-21569
Scientific objectives and functional requirements of life sciences in the Space Station p 154 A88-21570
Focus of attention in systems for visual monitoring of experiments p 112 A88-21858
Advanced protein crystal growth flight hardware for the Space Station
[AIAA PAPER 88-0345] p 3 A88-22253
Materials processing twin experiment
[AIAA PAPER 88-0346] p 163 A88-22255
Shuttle experiments to measure the optical environments surrounding large space structures
[AIAA PAPER 88-0432] p 14 A88-22321
Observations of ions generated on or near satellite surfaces
[AIAA PAPER 88-0434] p 130 A88-22323
Comments on the 'early experimental validation' session of the Second International Conference on Tethers in Space
[AIAA PAPER 88-0535] p 113 A88-22400
Lowering the costs of satellite operations - Lessons learned from the Solar Mesosphere Explorer (SME) mission
[AIAA PAPER 88-0540] p 7 A88-22412
Man Tended Free Flyer utilization aspects
[MBB-UR-E-981-87] p 142 A88-23981
The incredibly versatile space tether
p 114 A88-24454
In-space research, technology and engineering experiments and Space Station p 3 A88-27750
Absorptive tethers - A first test in space
p 115 A88-27781
Electrostatic analyzers design for space investigation
p 131 A88-29623
The space life sciences research and application in Europe p 143 A88-29106
The opportunities for space biology research on the Space Station p 155 A88-29134
Need, utilization, and configuration of a large, multi-G centrifuge on the Space Station p 155 A88-29140
NASA spaceborne optical disk recorder development
p 100 A88-29620
Biagov commentary on Mir station, first manning
p 144 N88-10661
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment
p 145 N88-12917
Research on Electrodynamic Tether Effects (RETE) experiment Electrical Ground Support Equipment (EGSE) — tethered satellite
[FSI-87-2] p 100 N88-13378
RETE experiment Assembly, Integration, and Verification (AIV) activities
[FSI-87-6] p 117 N88-13380
Allowable gravity levels for Spacelab, Columbus and EURECA — materials science
[BF-R-88.525-2] p 132 N88-15084
Microgravity Particle Research on the Space Station
[NASA-CP-2496] p 119 N88-15354
Astrophysics and the solar nebula
p 119 N88-15355
Planetary science p 5 N88-15356
Atmospheric physics p 5 N88-15357
Exobiology and life science p 119 N88-15358
Physics and chemistry p 119 N88-15359
A theoretical concept for static charges and shape changes in weightlessness p 157 N88-15365
Space station accommodations for life sciences research facilities. Phase 1: Conceptual design and programmatics studies for Missions SAAX0307, SAAX0302 and the transition from SAAX0307 to SAAX0302. Volume 2: Study results
[NASA-CR-179244] p 104 N88-15829
The NORSTAR Program: Space shuttle to space station p 167 N88-17710
Preliminary analysis of an integrated logistics system for OSSA payloads
[NASA-CR-4114] p 6 N88-19477
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 4: Supportability analysis of the 1.8m centrifuge p 6 N88-19481
Promising concepts for ground-to-orbit experiment teleoperation — Columbus p 93 N88-19518
Robotics servicing experiment — European space programs p 93 N88-19529
The European Space Agency's role in life sciences and research in space p 148 N88-19894
Exobiology and botany facilities for EURECA
p 148 N88-19898
Animal research on the Space Station
p 159 N88-19964

SPACEBORNE LASERS
Laser solar power satellites - A case study in technology forecasting p 68 A88-15492

SPACEBORNE TELESCOPES
EPM, the deployable mast for Columbus — Extendable and Retractable Mast p 11 A88-15278
An advanced imaging space telescope concept
[IAF PAPER 87-460] p 110 A88-16113
An operations concept for the Space Station based Astrometric Telescope Facility
[AIAA PAPER 88-0447] p 113 A88-22333
A telescope for high energy gamma-ray measurements in the Space Station era
[AIAA PAPER 88-0652] p 114 A88-22485
The X-ray large array. II - Implementation
[AIAA PAPER 88-0654] p 14 A88-22486
Wavefront error sensing
[NASA-CR-181504] p 75 N88-12030
Multisurface control mechanism for a deployable antenna: Far Infrared and Submillimeter Space Telescope (FIRST) technology study
[RP-FA-0003] p 120 N88-16807

SPACECRAFT ANTENNAS
Large inflatable, space-rigidized antenna reflectors - Land mobile services development
[IAF PAPER 87-315] p 12 A88-18013
Research and development of the tension truss antenna
[IAF PAPER 87-317] p 12 A88-18015
Techniques for assessment of flexible space structure control performance
[AIAA PAPER 88-0677] p 52 A88-22537
Proposal of adaptively controlled transmitting array for microwave power transmission in space
p 53 A88-25854
Prospects on future ESA communications
[AIAA PAPER 88-0767] p 78 A88-27542
An application of MSC/NASTRAN in the interdisciplinary analysis of large space-based structures
p 17 A88-29819
A composite structural system for a large collapsible space antenna p 19 A88-31403
Dynamics and control of spacecraft with retargeting flexible antennas
[AIAA PAPER 88-2414] p 57 A88-32341
Mechanical properties characterization of composite sandwich materials intended for space antenna applications
[NASA-TM-89893] p 25 N88-10121

SPACECRAFT CABIN ATMOSPHERES
Environmental control and life support system for Japanese Experiment Module
[SAE PAPER 871429] p 39 A88-21092
Experimental study for carbon dioxide removal system in Space Station
[SAE PAPER 871516] p 43 A88-21181
Design and development of the life support subsystem of a laboratory model of the Botany Facility
[SAE PAPER 871519] p 43 A88-21184
Progress in European CELSS activities
p 44 N88-12252

SPACECRAFT CABINS
Crewman rescue equipment in manned space missions - Aspects of application
[IAF PAPER 87-576] p 153 A88-16187
FACILE - A computer program for Space Station facilities layout and activity simulation
[SAE PAPER 871415] p 7 A88-21079
A smoke removal unit
[SAE PAPER 871449] p 153 AIR-21139
Space station group activities habitability module study: A synopsis p 6 N88-19886

SPACECRAFT CHARGING
The effect of photoelectrons on boom-satellite potential differences during electron beam ejection
[AD-A190390] p 75 A88-20350
A simple model for the initial phase of a water plasma cloud about a large structure in space
[AIAA PAPER 88-0430] p 95 A88-22320
Observations of ions generated on or near satellite surfaces
[AIAA PAPER 88-0434] p 130 A88-22323
Numerical analysis of interaction of a high-voltage solar array with ionospheric plasma p 72 A88-27986
Electrostatic analyzers design for space investigation
p 131 A88-29623
Space Environment Technology — conference
[ISBN-2-85428-170-5] p 132 N88-11702
External surface charging mechanisms — spacecraft
p 132 N88-11719
Modeling of environmentally-induced effects within satellites. Part 1: NASCAP modeling of satellites
p 58 N88-11721
Discharge phenomena — spacecraft
p 132 N88-11723

SPACECRAFT COMMUNICATION
Listening to the cosmonauts p 75 A88-13975
CAMERA: Expert System for Space Station communications and tracking system management — Control and Monitor Equipment Resource Allocation
p 75 A88-15295
The Flight Telerobotic Servicer (FTS) - A focus for automation and robotics on the Space Station
[IAF PAPER 87-25] p 82 A88-15817
Damming the data stream from space
p 98 A88-19869
Future European ground segment — for Columbus Space Station
[MBB-UR-E-976-87] p 142 A88-23980
Proposal of adaptively controlled transmitting array for microwave power transmission in space
p 53 A88-25854

SPACECRAFT COMPONENTS
Materials selection as related to contamination of spacecraft critical surfaces p 95 A88-26965
Fire-related standards and testing
p 158 N88-12522

212

Fire extinguishment and inhibition in spacecraft environments p 156 N88-12523
Natural frequencies and structural integrity assessment of large space structures
[AD-A186139] p 29 N88-10001
Space station structures development
[NASA-CR-179261] p 30 N88-16792

SPACECRAFT CONFIGURATIONS
Enhanced Eureca configuration operations p 134 A88-15295
Columbus: Attached Pressurized Module configuration - MTFF Pressurized Module configuration p 134 A88-15298
JEM present project status — Japan Experiment Module
[IAF PAPER 87-62] p 135 A88-15842
Automation and robotics technology application to JEM — Japanese Experiment Module
[IAF PAPER 87-74] p 136 A88-15849
The United States Space Station revised baseline
[IAF PAPER 87-81] p 152 A88-15855
Configuration drivers for the European Polar Platform
[IAF PAPER 87-104] p 137 A88-15873
Man Tended Free Flyer configurations and servicing scenarios
[MBB-UR-E-084-87] p 125 A88-23990
A 50 year scenario for the utilization of space to improve the quality of life on earth p 164 A88-27856
Dynamics and control characteristics of a reference Space Station configuration
[AIAA PAPER 88-2485] p 55 A88-31394
Mode shape identification and orthogonalization
[AIAA PAPER 88-2354] p 23 A88-32294
Adaptive control of Large Space Structure (LSS)
[ISAS-R-621] p 58 N88-11740
Payload configurations and serviceability — Columbus Polar Platforms p 117 N88-12133
The 1988 NASA (National Aeronautics and Space Administration) authorization
[GPO-80-245] p 166 N88-14044
Space station overview p 167 N88-16780
Space station structures development
[NASA-CR-179261] p 30 N88-16792
Coorbiting Platform Utilization Study (CPLUS): executive summary — Columbus
[SN-IMP-4000-DOC-4809-95/F] p 120 N88-16798
Analysis of a rotating advanced technology space station for the year 2025
[NASA-CR-179345] p 107 N88-19580

SPACECRAFT CONSTRUCTION MATERIALS
Advanced materials for ESA spacecraft p 133 A88-13580
Monitoring elastic anPhase degradation in graphite/epoxy composites p 14 A88-19173
Experiments to ensure Space Station fire safety - A challenge
[AIAA PAPER 88-0540] p 155 A88-22405
High temperature resistant compliant modified epoxies p 95 A88-29585
Large space structures - Structural concepts and materials
[SAE PAPER 872429] p 17 A88-30999
AIAA SDM issues of the International Space Station, Conference, Williamsburg, VA, Apr 21,22, 1988, Technical Papers p 17 A88-31376
Structures and materials technology for Space Station
[AIAA PAPER 88-2446] p 17 A88-31377
Development and properties of aluminum-clad graphite/epoxy tubes for space structures
[AIAA PAPER 88-2472] p 18 A88-31389
Response of composite materials to the Space Station orbit environment
[AIAA PAPER 88-2478] p 95 A88-31390
Stress rupture behavior of carbon-fiber metal-lined pressure vessels for 30-year operation in space
[AIAA PAPER 88-2479] p 19 A88-31391
Outgassing of spacecraft composites p 95 A88-31404
Outgassing data for selecting spacecraft materials
[NASA-RP-1124] p 95 N88-10117
High intensity 5 eV O-atom exposure facility for material degradation studies p 96 N88-10847
Spacecraft surface exposure to atomic oxygen in low Earth orbit p 96 N88-11715
Discharge phenomena — spacecraft p 152 N88-11723
Discharge prevention of geosynchronous orbit conductive thermal control materials and grounding systems p 76 N88-11732
Fire-related standards and testing p 154 N88-12522
Spacecraft material flammability testing and configurations p 96 N88-12529
Carbon fiber reinforced glass matrix composites for space based applications
[AD-A184958] p 96 N88-12546
Space environmental effects on polymeric materials
[NASA-CR-182454] p 97 N88-16979

SPACECRAFT CONTAMINATION
A measurement of the angular distribution of 5 eV atomic oxygen scattered off a solid surface in earth orbit p 130 A88-19866
Assessment of external contamination for Space Station scientific payloads
[SAE PAPER 871476] p 130 A88-21131
Large space systems environmental entanglements
[AIAA PAPER 88-0366] p 14 A88-22396
A simple model for the initial phase of a water plasma cloud about a large structure in space
[AIAA PAPER 88-0430] p 95 A88-22520
Materials selection as related to contamination of spacecraft critical surfaces p 95 A88-26965
Fourteenth Space Simulation Conference: Testing for a Permanent Presence in Space
[NASA-CP-2446] p 5 N88-10829
Contamination control concepts for space station customer servicing p 121 N88-10860
Spacecraft surface exposure to atomic oxygen in low Earth orbit p 96 N88-11715
Analysis of geophysical data bases and models for spacecraft interactions
[AD-A184809] p 100 N88-13375

SPACECRAFT CONTROL
Theoretical principles of the optimal control of flexible spacecraft — Russian book p 47 A88-19050
Autonomous spacecraft operations - Problems and solutions
[AIAA PAPER 87-2850] p 91 A88-12571
Feedback control for attitude control system of the elastic vehicle p 48 A88-14596
Design and development of a computer assisted ground control technique for Space Station robotics p 82 A88-15284
A unified matrix approach applied to dynamic formulation of complex space structures with nonlinear hinge forces and torques
[IAF PAPER 87-349] p 13 A88-16038
The dynamics and control of large space structures after the onset of thermal shock
[IAF PAPER 87-351] p 49 A88-16041
Mission function control applied to slew maneuver
[IAF PAPER 87-354] p 49 A88-16044
The passive attitude motion of the orbital stations Salyut-6 and Salyut-7
[IAF PAPER 87-355] p 49 A88-16045
Acceleration measurement and management on a space station
[IAF PAPER 87-364] p 50 A88-16049
Automatic control in space 1988 p 50 A88-16276
Design-to-performance — of controllers for Space Stations p 2 A88-16295
Application of adaptive observers to the control of flexible spacecraft p 50 A88-16296
A free-flying power plant for a manned space station p 75 A88-16309
Modeling and simulation of distributed flexibility in a spaceborne manipulator p 83 A88-16309
Guidance and control 1987: Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Jan. 31-Feb. 4, 1987 p 51 A88-16976
Simulation and control of a Space Station air revitalization system
[SAE PAPER 871425] p 7 A88-21089
Controlling real-time processes on the Space Station with expert systems p 84 A88-21634
Efficient spacecraft formationkeeping with consideration of ballistic coefficient control
[AIAA PAPER 88-0375] p 124 A88-22277
Tether technology - Conference summary
[AIAA PAPER 88-0533] p 115 A88-22398
Space Station attitude control momentum requirements
[AIAA PAPER 88-0672] p 51 A88-22502
Maneuvering and vibration control of flexible spacecraft p 52 A88-22930
Attitude control of a three rotor gyrostat in the presence of uncertainty p 52 A88-22933
Decentralized hierarchical control for large flexible spacecraft
[MBB-UR-967-87] p 52 A88-23992
Robust stabilization under mode truncation and parameter variations p 15 A88-27325
Information prioritization for control and automation of space operations p 86 A88-27355
Decentralized control of third generation spacecraft p 15 A88-27356
A survey of decentralized control techniques for large space structures p 16 A88-27358
Three axis rotational maneuver and vibration stabilization of elastic spacecraft p 54 A88-27364
Design of robust line-of-sight pointing control system for the SCOLE configuration p 54 A88-27367
Sensor and actuator selection for optimal closed-loop performance in the presence of correlated noise p 54 A88-27397
A homotopy algorithm for solving the optimal projection equations for fixed-order dynamic compensation - Existence, convergence and global optimality p 16 A88-27401
Momentum management and attitude control design for a Space Station p 55 A88-28253
Dynamics and control characteristics of a reference Space Station configuration
[AIAA PAPER 88-2485] p 55 A88-31394
Dynamics and control of spacecraft with retargeting flexible antennas
[AIAA PAPER 88-2414] p 57 A88-32341
Dynamics of spacecraft control laboratory experiment (SCOLE) slew maneuvers
[NASA-CR-4098] p 57 N88-10082
Attitude Control Working Group report p 57 N88-10099
Predictive momentum management for a space station measurement and computation requirements
[NASA-CR-172026] p 58 N88-10866
Adaptive control of Large Space Structure (LSS)
[ISAS-R-621] p 58 N88-11740
Now feedback design methodologies for large space structures: A multi-criterion optimization approach p 59 N88-12535
Combined problem of slew maneuver control and vibration suppression
[NASA-CR-181537] p 59 N88-12917
Modeling and control of large flexible vehicles in the atmosphere and space
[AD-A185368] p 27 N88-13377
Optimal control of large space structures via generalized inverse matrix
[NASA-CR-182236] p 59 N88-13967
Expert system study for spacecraft management
[TL-2699-155-1] p 101 N88-15884
The dynamics and control of large flexible space structures, part 10
[NASA-CR-182436] p 29 N88-15830
Large-angle slewing maneuvers for flexible spacecraft
[NASA-CR-4129] p 60 N88-16080
Gyrostabilizer system of Kvant module p 60 N88-16099
Third Conference on Artificial Intelligence for Space Applications, part 1
[NASA-CP-2492-Pt-1] p 89 N88-16360
KBS V and V as related to automation of space station subsystems: Rationale for a KBS lifecycle p 9 N88-16375
Applications of expert systems for satellite autonomy p 90 N88-16443
Development of a coupled expert system for the spacecraft attitude control problem p 61 N88-17223
Expert system applications in spacecraft subsystem controllers p 90 N88-17254
Formulation methods of rigid multibody systems for large space structures and some results of computer simulation
[NAL-TR-942] p 30 N88-17730

SPACECRAFT DESIGN
Spacecraft solar array substrate development p 68 A88-13187
ERM, the deployable mast for Columbus — Extensible and Retractable Mast p 11 A88-15279
MTFF operational design features p 134 A88-15296
Membraneless X-ray detector and spacecraft design study p 109 A88-15511
Conceptual design of the advanced technology platform
[IAF PAPER 87-02] p 109 A88-15802
Thermal design of the equipment platforms
[IAF PAPER 87-05] p 34 A88-15806
Spacecraft technology trends - A view from the past
[IAF PAPER 87-07] p 161 A88-15807
Environmental constraints for Polar Platform design
[IAF PAPER 87-09] p 108 A88-15809
United States Space Station technical and programmatic interfaces
[IAF PAPER 87-65] p 162 A88-15844
The impact of launch vehicle constraints on U.S. Space Station design and operations
[IAF PAPER 87-72] p 2 A88-15848
Space Station services and design features for users
[IAF PAPER 87-86] p 163 A88-15870
Concept studies for a laser powered Orbital Transfer Vehicle
[IAF PAPER 87-200] p 77 A88-15897
Structural design and decoupled control — of large space structures
[IAF PAPER 87-218] p 48 A88-16018

213

Capabilities and special features concerning structural optimization of spacecraft structures
[IAF PAPER 87-320] p 17 A88-16018
Angular momentum management for LEO platforms
[IAF PAPER 87-340] p 43 A88-16039
A conceptual design for a single-stage-to-orbit Space Station Service vehicle
[IAF PAPER 87-ST-07] p 2 A88-16071
Low-cost prototypes for human factors evaluation of Space Station crew equipment
[IAF PAPER 87-552] p 142 A88-16170
Assembling the Space Station p 123 A88-20475
FACILE - A computer program for Space Station facilities layout and activity simulation
[SAE PAPER 871415] p 7 A88-21079
Fokker subsystem responsibilities in Columbus B phase studies p 141 A88-21561
Aerospatiale studies for IOC and AOC — Initial Operational Capability and Autonomous Operating Capability p 141 A88-21562
Human exploration of Mars — assessment of technology requirements
[AIAA PAPER 88-0384] p 105 A88-22044
A conceptual design for a single-stage-to-orbit Space Station service vehicle
[AIAA PAPER 88-0389] p 3 A88-22063
Large deployable reflector thermal characteristics in low earth orbits
[AIAA PAPER 88-0471] p 36 A88-22147
Tether technology - Conference summary
[AIAA PAPER 88-0533] p 113 A88-22398
New radiator system designed for large spacecraft p 36 A88-25368
Small reentry vehicles p 150 A88-26364
Structural decomposition approach to design of robust decentralized controllers for large scale systems p 53 A88-27358
A criterion for shape control robustness of space structures p 16 A88-29720
Roll-out-fin expandable space radiator concept p 36 A88-30320
Design and analysis of passively damped large space structures p 58 A88-31574
Spacecraft 2000 program overview p 185 N88-10080
Space station platforms p 116 N88-10086
Space Assembly, Maintenance, and Servicing Study (SAMSS) p 125 N88-10089
Spacecraft Systems Working Group report p 165 N88-10091
Structures and Materials Working Group report p 25 N88-10093
Thermal Control Working Group report p 36 N88-10094
Aeroassisted manned transfer vehicle (TAV) for advanced Mars Transportation NASA/USRA 1987 Senior Design Project
[NASA-CR-181479] p 136 N88-11736
Adaptive control of Large Space Structure (LSS)
[ISAS-R-621] p 58 N88-11740
Space station integrated propulsion and fluid system study: Fluid systems configuration database
[NASA-CR-179015] p 79 N88-11753
New feedback design methodologies for large space structures: A multi-criterion optimization approach p 59 N88-12535
Airborne particulate matter in spacecraft
[NASA-CP-2486] p 157 N88-14823
Safety philosophy, policy, and requirements for manned spaceflight. Volume 1: Executive summary
[HEG-0886/1036-VOL-1] p 157 N88-15826
Space station accommodations for life sciences research facilities. Phase 1: Conceptual design and programmatics studies for Missions 'SAAX0307, SAAX0302 and the transition from SAAX0307 to SAAX0302. Volume 2: Study results
[NASA-CR-179044] p 104 N88-15829
FME Assist: A knowledge-based approach to Failure Modes and Effects Analysis p 101 N88-16395
Space station overview p 167 N88-16780
The Columbus program, an overview p 140 N88-16784
Columbus feasibility studies. Volume 1: Requirements and system concept
[ETN-88-91073] p 146 N88-16799
Columbus feasibility studies. Volume 2: Element constituents, mechanical
[ETN-88-91074] p 146 N88-16800
Columbus feasibility studies. Volume 3: Avionics, systems
[ETN-88-91075] p 146 N88-16801
Model of space platform electromagnetic (EMC) configuration
[ESA-CR(P)-2580] p 9 N88-16809
Kinetic isolation tether experiment
[NASA-CR-182456] p 120 N88-16810
Design knowledge capture for the space station p 9 N88-17238
Non-Tended Free Flyer operational design features p 128 N88-19486
Multimission Modular Spacecraft (MMS): A serviceable design spacecraft p 6 N88-19501
Columbus Simulation Facility (CSF) p 148 N88-19522
Space station architecture elements model study. Space stay on human factors research review p 102 N88-19884
Radiation problems in manned space flight with a view to the Space Station p 132 N88-19934

SPACECRAFT DOCKING

Laser Docking System Radar flight experiment p 47 A88-12914
Simulation tools for the development of an autonomous rendezvous and docking system p 47 A88-13572
Rendezvous and docking technology for future European missions p 48 A88-15280
Coordination of free-flyers
[IAF PAPER 87-14] p 108 A88-15611
Scanning laser radar system for rendezvous and docking in space
[IAF PAPER 87-53] p 48 A88-15838
Control techniques for rendezvous and docking p 51 A88-16311
Mir - Soviet base in space p 129 A88-16378
Soviet shuttle for Space Station role p 136 A88-19700
Video-based satellite attitude determination p 51 A88-21657
EPOS - A facility for simulating operations near spacecraft p 58 A88-32145
Blagov commentary on Mir station, first manning p 144 N88-10031
Rendezvous and Docking Verification (RVDV) and in-orbit demonstration, executive summary
[RVD-RVDV-FR-AS-01] p 127 N88-14120
Docking/Berthing Subsystem (DBS). Development part 1: Latching analysis — Columbus
[ESA-CR(P)-2479] p 60 N88-15825
Rendezvous and docking verification and demonstration in orbit, executive summary
[MBB-303-16-96] p 61 N88-17719
Space vehicle approach velocity judgments under simulated visual space conditions
[NASA-TM-89437] p 158 N88-19094
Analyses of RVD operations in manned space missions p 61 N88-19494
Motion simulation for in-orbit operations p 62 N88-19514
EPOS: European Proximity Operations Simulation p 147 N88-19515
Dynamic testing of a docking system — ground-based simulator p 62 N88-19516
Rendezvous and docking (RVD) verification and demonstration in-orbit p 62 N88-19531

SPACECRAFT ELECTRONIC EQUIPMENT

Spacecraft 2000
[NASA-CP-2473] p 108 N88-10084

SPACECRAFT ENVIRONMENTS

Radiation problems with the Space Station scenario and the necessary surveillance for astronauts
[IAF PAPER 87-542] p 129 A88-16180
Support of life science research in space by the DFVLR Microgravity User Support Center (MUSC)
[IAF PAPER 87-544] p 152 A88-16182
A computer aided engineering tool for ECLS systems
[SAE PAPER 871425] p 98 A88-21087
G189 computer program: modeling of environmental control and life support systems for the Space Station
[SAE PAPER 871427] p 39 A88-21090
Spacecraft water system disinfection technology - Past, present, and future needs
[SAE PAPER 871487] p 41 A88-21141
Consequences of bacterial resistance to disinfection by iodine in potable water
[SAE PAPER 871489] p 42 A88-21143
Medical effects of iodine disinfection products in spacecraft water
[SAE PAPER 871490] p 154 A88-21144
Status of the Space Station water reclamation and management subsystem design concept
[SAE PAPER 871510] p 42 A88-21156
Optical fiber waveguides for spacecraft applications p 95 A88-21919
New radiator system designed for large spacecraft p 36 A88-25368
Fourteenth Space Simulation Conference: Testing for a Permanent Presence in Space
[NASA-CP-2446] p 5 N88-10829
Space station contamination considerations p 131 N88-10859
Contamination control concepts for space station customer servicing p 131 N88-10860
Spacecraft Fire Safety
[NASA-CP-2476] p 158 N88-12520
Fire extinguishment and inhibition in spacecraft environments p 158 N88-12523
Fire-related medical science p 158 N88-12525
Space station internal environmental and safety concerns p 158 N88-12527
Microgravity combustion fundamentals p 79 N88-12528
Spacecraft material flammability testing and configurations p 96 N88-12529
Analysis of geophysical data bases and models for spacecraft interactions
[AD-A184669] p 100 N88-13375
Controlled Ecological Life Support Systems (CELSS) conceptual design option study
[NASA-CR-177421] p 44 N88-14625
Controlled Ecological Life Support Systems (CELSS) physicochemical waste management systems evaluation
[NASA-CR-177422] p 45 N88-14626
Some considerations on measuring the fourth-man gravitational constant G in an orbiting laboratory p 119 N88-15602
Goal driven kinematic simulation of flexible arm robot for space station missions p 89 N88-15398
Spacecraft fire detection and extinguishment: A bibliography
[NASA-CR-183660] p 158 N88-19612
NASDA's new test facilities for satellites and rockets p 147 N88-19951

SPACECRAFT EQUIPMENT

Thermal design of the equipment platforms
[IAF PAPER 87-08] p 34 A88-15806
A dishwasher for the Space Station
[SAE PAPER 871411] p 38 A88-21078
The use of computer graphic simulation in the development of on-orbit tele-robotic systems p 95 A88-21646
Advanced protein crystal growth flight hardware for the Space Station
[AIAA PAPER 88-0345] p 3 A88-22253
Development of a master slave manipulator system for space use p 86 A88-26975
Space station accommodations for life sciences research facilities. Phase 1: Conceptual design and programmatics studies for Missions SAAX0307, SAAX0302 and the transition from SAAX0307 to SAAX0302. Volume 2: Study results
[NASA-CR-179044] p 104 N88-15829
Development of the Extendable and Retractable Mast (ERM). Design phase 2. Volume 1: — spacecraft payloads
[RP-2010-0000-DS/09] p 31 N88-19750
Covariant control of bilateral servos for in-orbit manipulation p 62 N88-19520
A comparative survey of mathematical models for dynamic simulation of in-orbit manipulation operations p 148 N88-19533

SPACECRAFT GLOW

True energy atmospheric emulator for low earth orbit species
[AIAA PAPER 88-0727] p 3 A88-22549

SPACECRAFT GUIDANCE

Guidance and control 1987; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Jan. 31-Feb. 4, 1987 p 51 A88-16976
An analysis of the effect of aeroassist maneuvers on orbital transfer vehicle performance
[NASA-TM-89117] p 150 N88-14116
Aeroassisted orbit transfer vehicle trajectory analyses
[NASA-TM-89138] p 62 N88-19575

SPACECRAFT LANDING

Applications of expert systems for satellite autonomy p 90 N88-19443

SPACECRAFT LAUNCHING

Economic benefits of the Space Station to commercial communication satellite operators
[IAF PAPER 87-622] p 160 A88-16215
1986 - Very good year for Soviets p 139 A88-16379
Department of Housing and Urban Development-Independent Agencies Appropriations for fiscal year 1988. Thursday, 9 April 1987. National Aeronautics and Space Administration p 166 N88-12424

SPACECRAFT MAINTENANCE

Technology advancements for servicing of future spacecraft systems
[IAF PAPER 87-36] p 122 A88-15828
Hubble Space Telescope servicing - Experience base for a new era
[IAF PAPER 87-38] p 109 A88-15829
Assembling, maintaining and servicing Space Station
[IAF PAPER 87-43] p 123 A88-15859

214

Columbus pressurized modules: Maintenance and supply concepts - Approach and development for a Space Station long term support
[IAF PAPER 87-66] p 137 A88-15960
Development of an automated checkout, service, and maintenance system for an EVAS Space Station
[SAE PAPER 871497] p 134 A88-21149
The Solar Maximum Mission repair - Lessons learned p 134 A88-21653
Space Station pressure wall repair techniques
[AIAA PAPER 88-2468] p 19 A88-31397
Long-life assurance for Space Station - Is it an issue?
[AIAA PAPER 88-2469] p 43 A88-31398
Remote manipulation on orbital construction, servicing and repair missions: Is one arm enough? A comparative evaluation of the performance features of robots with one or more arms p 90 N88-19509
Remote repair demonstration of Solar Maximum main electronics box p 129 N88-19510
Treatment of unforeseen situations by online knowledge-based diagnostic systems --- spacecraft maintenance p 93 N88-19511
Review of commercial spacecraft: Recovery and repair experiences, implications for future spacecraft designs and operations p 129 N88-19529

SPACECRAFT MANEUVERS

Mission function control applied to slew maneuver
[IAF PAPER 87-334] p 49 A88-16044
Feedback control design for smooth, near minimum time rotational maneuvers of flexible spacecraft
[AIAA PAPER 88-0671] p 51 A88-22301
Minimum time attitude slewing maneuvers of a rigid spacecraft
[AIAA PAPER 88-0675] p 52 A88-22505
Maneuvering and vibration control of flexible spacecraft p 52 A88-22932
Attitude control of a three rotor gyrostat in the presence of uncertainty p 52 A88-22933
Flexible spacecraft maneuver - Inverse attitude control and modal stabilization p 53 A88-24291
Three axis rotational maneuver and vibration stabilization of elastic spacecraft p 54 A88-27364
Dynamics and control of spacecraft with retargeting flexible antennas
[AIAA PAPER 88-2419] p 57 A88-32341
An analysis of the effect of aerassist maneuvers on orbital transfer vehicle performance
[NASA-TM-89107] p 150 N88-14118
Dynamics formulations for the real-time simulation of constrained motion p 90 N88-14872
The dynamics and control of large flexible space structures, part 10
[NASA-CR-182426] p 29 N88-15830
Large-angle slewing maneuvers for flexible spacecraft
[NASA-CR-4123] p 90 N88-16060
EPOS: European Proximity Operations Simulation p 147 N88-19515

SPACECRAFT MODELS

Reduced order models of a large flexible spacecraft
[IAF PAPER 87-356] p 13 A88-16046
Efficient placement of structural dynamics sensors on the space station
[NASA-CR-172015] p 25 N88-10103
Modeling of environmentally-induced effects within satellites. Part 1: NASCAP modeling of satellites p 58 N88-11721
Thermal structural control modeling techniques --- spacecraft
[FOK-TR-R-88-030] p 39 N88-19828
Columbus Simulation Facility (CSF) p 148 N88-19522

SPACECRAFT MODULES

Preparing for the future --- NASA Space Station program p 110 A88-10366
Columbus takes shape - Europe's Space Station approaches decision time p 132 A88-10678
Crew factors in the design of the Space Station p 151 A88-10947
Applications for power control within a Space Station module p 67 A88-11804
Disturbance and vibration isolation in space stations by means of mechanical decoupling p 11 A88-13932
Space Station ground data management system p 96 A88-15282
SpaceHab - A manned Space Station testbed p 103 A88-15287
The Canadian Mobile Servicing System for Space Station servicing p 62 A88-15289
Development of the resource module for the European space station programme Columbus p 134 A88-15294
Columbus: Attached Pressurized Module configuration - MTFF Pressurized Module configuration p 134 A88-15298
JEM present project status --- Japan Experiment Module
[IAF PAPER 87-61] p 135 A88-15942
Evolution towards an autonomous European manned space infrastructure
[IAF PAPER 87-67] p 136 A88-15944
Automation and robotics technology application to JEM --- Japanese Experiment Module
[IAF PAPER 87-74] p 136 A88-15949
Man tended free flyer interior equipment for manned and automated operation
[IAF PAPER 87-75] p 136 A88-15950
Columbus pressurized modules - A challenging opportunity for microgravity research and application
[IAF PAPER 87-375] p 137 A88-16050
The high-flying Kuipit module p 139 A88-20457
Intermodule ventilation studies for the Space Station
[SAE PAPER 871428] p 130 A88-21091
Columbus ECLSS
[SAE PAPER 871430] p 139 A88-21093
Thermal control definition of Columbus pressurized modules
[SAE PAPER 871460] p 139 A88-21136
The Spacehab module passive thermal control
[SAE PAPER 871558] p 35 A88-21154
The Columbus Attached Pressurized Module - System and management aspects of international cooperation p 139 A88-21252
The Columbus system aspects p 140 A88-21256
Columbus pressurized module p 140 A88-21557
The Resource Module p 140 A88-21559
Man Tended Free Flyer configurations and servicing scenarios
[MBB-UR-E 064-87] p 125 A88-23966
Design and verification of the FLECS test structure --- Flexible ECS-type structure p 54 A88-27779
U.S. Space Platform firms aim for 1991 service start p 164 A88-27954
Space station internal environmental and safety concerns p 156 N88-12527
Controlled Ecological Life Support Systems (CELSS) conceptual design option study
[NASA-CR-177421] p 44 N88-14625
Columbus pressurized module utilization study: executive summary
[CS-RP-AI-027] p 146 N88-15005
Satellite assembly in geostationary orbit: A plug and socket concept p 127 N88-16769
Space station overview p 167 N88-16780
Columbus feasibility studies. Volume 2: Element constituents, mechanical
[ETN-88-91074] p 146 N88-16800
In-orbit and laboratory exchange of ORUs designed not designed for servicing p 151 N88-19499
Multimission Modular Spacecraft (MMS): A serviceable design spacecraft p 6 N88-19501

SPACECRAFT MOTION

Formulation of rigid multibody systems in space p 14 A88-21221
Dynamics of earth-orbiting flexible satellites with multibody components p 52 A88-22609
Concept definition study for recovery of tumbling satellites. Volume 1: Executive summary, study results
[NAR A-CR-179206] p 127 N88-14119

SPACECRAFT ORBITS

Efficient spacecraft formationkeeping with consideration of ballistic coefficient control
[AIAA PAPER 88-0375] p 124 A88-22277

SPACECRAFT PERFORMANCE

Evolutionary Space Station infrastructure
[IAF PAPER 87-103] p 105 A88-15872
Columbus operation and utilization p 141 A88-21563
Columbus utilization preparation - Status of ongoing studies p 141 A88-21565
Orbit lifetime characteristics for Space Station
[AIAA PAPER 88-2480] p 55 A88-31399
RETE experiment Assembly, Integration, and Verification (AIV) activities
[FSI-87-6] p 117 N88-13380
Why mechanisms are critical to spacecraft performance p 80 N88-16737

SPACECRAFT POWER SUPPLIES

Solar receiver for the Space Station Brayton engine
[ASME PAPER 87-GT-252] p 62 A88-11134
IECEC '87; Proceedings of the Twenty-second Intersociety Energy Conversion Engineering Conference, Philadelphia, PA, Aug. 10-14, 1987. Volumes 1, 2, 3, & 4 p 63 A88-11776
Advanced photovoltaic solar array design p 63 A88-11793
Ross-Stirling engine - A high performance dynamic space power system p 63 A88-11797
Advanced solar receiver conceptual design study p 64 A88-11800
Selection of high temperature thermal energy storage materials for advanced solar dynamic space power systems p 64 A88-11801
Optimization and analysis of lithium hydride thermal energy storage device configurations for space power applications p 64 A88-11802
Fluoride salts and container materials for thermal energy storage applications in the temperature range 973 - 1400 K p 32 A88-11804
Radiator selection for Space Station Solar Dynamic Power Systems p 32 A88-11806
Comparison of high temperature heat rejection concepts to system-related requirements p 33 A88-11809
An evaluation of heat pipe radiators incorporating pumped liquid return p 33 A88-11810
A novel photovoltaic power system which uses a large area concentrator mirror p 65 A88-11811
Development of an advanced photovoltaic concentrator system for space applications p 65 A88-11812
Preliminary conceptual design and weight of a one-megawatt space-based laser power station utilizing a solar-pumped iodine laser p 65 A88-11816
Electrical power system for low earth orbit spacecraft applications p 65 A88-11817
Design techniques for 20K Hz power converters p 66 A88-11822
Intelligent fault detection and power system protection for spacebome systems p 66 A88-11826
Control considerations for high frequency, resonant, power processing equipment used in large systems p 47 A88-11829
EMC and power quality standards for 20 kHz power distribution p 66 A88-11830
Comparative study of cable construction for 20 kHz power distribution p 66 A88-11831
Automated load management for spacecraft power systems p 67 A88-11863
Coaxial tube array space transmission line characterization p 75 A88-11885
Power and resource management scheduling for scientific space platform applications p 109 A88-11890
Expert system for fault detection and recovery for a space based power management and distribution system p 68 A88-11892
The evolution of space power systems technology
[IAF PAPER 87-026] p 54 A88-15852
Collector and receiver designs for high temperature Brayton cycle for space application
[IAF PAPER 87-228] p 69 A88-15893
Space Station Electrical Power System
[IAF PAPER 87-234] p 69 A88-15898
Aspects and possibilities of an integrated energy and media supply system on H2/O2 basis for manned space stations in the low earth orbit
[IAF PAPER 87-241] p 39 A88-15963
Past, present and future activities in space power technology in the UK
[IAF PAPER 87-243] p 69 A88-15964
Past, present, and future activities in space power technology in the United States of America
[IAF PAPER 87-245] p 69 A88-15966
Plasmoid power station
[IAF PAPER 87-250] p 69 A88-15969
Dynamic power generation for solar power satellites
[IAF PAPER 87-253] p 69 A88-15972
Power requirements for an orbiting space farm
[IAF PAPER 87-242] p 70 A88-15980
Electrical power for Columbus - An important cross-element task p 140 A88-21560
Space solar cell research - Problems and potential p 70 A88-21605
Space nuclear power systems 1986; Proceedings of the Third Symposium, Albuquerque, NM, Jan. 13-16, 1986 p 71 A88-22676
Space power needs and forecasted technologies for the 1990s and beyond p 71 A88-22677
Monolithic fuel cell based power source for burst power generation p 71 A88-22691
Space based nuclear microwave electric propulsion p 78 A88-22706
Proposal of adaptively controlled transmitting array for microwave power transmission in space p 53 A88-25854
Environmental interactions of solar generators in space p 72 N88-11730
Photovoltaic power modules for NASA's manned space station
[NASA-TM 100229] p 72 N88-11745
The ac power system testbed
[NASA-CR-179068] p 72 N88-11948
Low Earth orbit environmental effects on the space station photovoltaic power generation systems
[NASA-TM-100230] p 73 N88-12429

215

Study of Plasma Motor Generator (PMG) tether system for orbit reboost
[NASA-CR-172016] p 117 N88-12501
Space station resistojet system requirements and interface definition study
[NASA-CR-180832] p 80 N88-12541
The effect of maximum-allowable payload temperature on the mass of a multimegawatt space-based platform
[DE88-001921] p 37 N88-13381
The high performance solar array GSRD
[SNIAS-872-422-106] p 73 N88-13814
Status of 20 kHz space station power distribution technology
[NASA-TM-100781] p 73 N88-15838
Artificial intelligence and space power systems automation p 84 N88-16381
Study of large solar arrays (SOLA), phase 2A
[BAE-SS/1109] p 74 N88-17106
Study of Large Solar Arrays (SOLA) Phase 2A: Amplifying information to final report (SS/1109)
[BAE-SS/1110] p 74 N88-17480
Simulation test beds for the space station electrical power system
[NASA-TM-100786] p 74 N88-17715
Computer-aided modeling and prediction of performance of the modified Lundell class of alternators in space station solar dynamic power systems
[NASA-CR-182538] p 74 N88-19000

SPACECRAFT PROPULSION
Optimization of the energy systems of manned orbital stations - Mathematical modeling and selection of efficient structures — Russian book p 68 A88-15664
Water-propellant resistojets for man-tended platforms
[IAF PAPER 87-259] p 78 A88-15975
Orbital Maneuvering Vehicle (OMV) propulsion subsystem
[IAF PAPER 87-261] p 149 A88-15976
Space nuclear power systems 1986; Proceedings of the Third Symposium, Albuquerque, NM, Jan. 13-16, 1986 p 71 A88-22676
Spacecraft 2000
[NASA-CP-2473] p 106 N88-10084
Space station propulsion
[NASA-TM-100216] p 79 N88-11746
Space station onboard propulsion system Technology study
[NASA-CR-179233] p 80 N88-15006
Space station propulsion technology
[NASA-CR-179260] p 80 N88-15835

SPACECRAFT RADIATORS
Radiator selection for Space Station Solar Dynamic Power Systems p 32 A88-11806
Heat pipe radiators for solar dynamic space power system heat rejection p 33 A88-11807
Comparison of high temperature heat rejection concepts to system-related requirements p 33 A88-11809
An evaluation of heat pipe radiators incorporating pumped liquid return p 33 A88-11810
Performance characteristics of moving belt radiators — for spacecraft applications p 33 A88-12006
Modelling the performance of the monogroove with screen heat pipe for use in the radiator of the solar dynamic power system of the NASA Space Station
[IAF PAPER 87-238] p 34 A88-15960
Hybrid honeycomb panel heat rejection system
[SAE PAPER 871419] p 34 A88-21083
Space Station body mounted radiator design
[SAE PAPER 871507] p 35 A88-21153
High thermal-transport capacity heat pipes for space radiators
[SAE PAPER 871509] p 35 A88-21155
Thermal contact conductance in the presence of thin metal foils
[AIAA PAPER 88-0466] p 35 A88-22342
Space erectable radiator system development
[AIAA PAPER 88-0469] p 36 A88-22345
New radiator system designed for large spacecraft p 36 A88-25368
Fluid loss from a puncture of a space radiator p 72 A88-30317
Roll-out-fin expandable space radiator concept p 36 A88-30320
Considerations concerning a thermal joint for a deployable or steerable battery radiator for the Columbus Polar Platform
[NLR-TR-86055-U] p 37 N88-11739
The effect of maximum-allowable payload temperature on the mass of a multimegawatt space-based platform
[DE88-001921] p 37 N88-13381

SPACECRAFT RECOVERY
Concept definition study for recovery of tumbling satellites. Volume 1: Executive summary, study results
[NASA-CR-179228] p 127 N88-14118
Rendezvous and Docking Verification (RVDV) and in-orbit demonstration, executive summary
[RVD-RVDV-FR-AS-01] p 127 N88-14120
Review of commercial spacecraft Recovery and repair experiences. Implications for future spacecraft designs and operations p 128 N88-19528

SPACECRAFT RELIABILITY
Dynamics of orbiting debris clouds and the resulting collision hazard to spacecraft
[IAF PAPER 87-571] p 129 A88-16183
Fault tolerant onboard implementation of control procedures in tethered satellite p 110 A88-16285
REPPRE-REPSIM-REPSTA - Programs for evaluating the availability and maintenance of space systems p 125 A88-27778
Long-life assurance for Space Station - Is it an issue?
[AIAA PAPER 88-2489] p 43 A88-31398
Natural frequencies and structural integrity assessment of large space structures
[AD-A186139] p 29 N88-15001

SPACECRAFT SHIELDING
Radiation hazards on space missions p 130 A88-22919
Analysis of oblique hypervelocity impact phenomena
[AIAA PAPER 88-2370] p 23 A88-32307
Optimization techniques applied to passive measures for in-orbit spacecraft survivability
[NASA-CR-179216] p 5 N88-12532

SPACECRAFT STABILITY
Stability of the steady motions of an electromagnetic tether system in orbit p 107 A88-11234
Feasibility study of a stabilizer fin for the tethered satellite system p 111 A88-16860
Rotation stability of a deformable flight vehicle p 144 A88-30115
Spillover stabilization of large space structures
[AIAA PAPER 88-2484] p 55 A88-31393
Pinhole occulter experiment
[NASA-CR-179206] p 116 N88-11481
Concept definition study for recovery of tumbling satellites. Volume 1: Executive summary, study results
[NASA-CR-179228] p 127 N88-14118

SPACECRAFT STRUCTURES
Spacecraft solar array substrate development p 68 A88-13187
Novel composite materials for space structures and systems p 10 A88-13188
Stress and deformation analysis and tests of composite structures for space application
[IAF PAPER 87-312] p 12 A88-16011
Space Station assembly - Techniques and structures p 104 A88-26420
Structural testing on the multi-axis simulator - An innovative simulation system for space-vehicle structures p 17 A88-29725
AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers p 17 A88-31376
Structural tailoring and feedback control synthesis - An interdisciplinary approach
[AIAA PAPER 88-2206] p 21 A88-32177
Experimental studies of active members in control of large space structures
[AIAA PAPER 88-2207] p 56 A88-32178
Spacecraft surface exposure to atomic oxygen in low Earth orbit p 96 N88-11715
Computational methods for problems in aerodynamics and large space structure using parallel and vector architectures
[AD-A185401] p 27 N88-13294
Viscous damped space structure for reduced jitter p 28 N88-13623
Thermal structural control modelling techniques — spacecraft
[FOK-TR-R-86-030] p 38 N88-15828
Analytical interactive approach for phenomena involving structures, thermal and control aspects. Volume 1: Theory — spacecraft structures
[ESA-CR(P)-2503-VOL-1] p 60 N88-16803
Analytical interactive approach for phenomena involving structures, thermal, and control aspects. Volume 2: Toward the solution — spacecraft structures
[ESA-CR(P)-2503-VOL-2] p 60 N88-16804
Analytical interactive approach for phenomena involving structures, thermal, and control aspects. Volume 3: Executive summary — spacecraft structures
[ESA-CR(P)-2503-VOL-3] p 60 N88-16805
Integrity control of carbon fiber reinforced plastics (CFRP) structural elements. Conclusion with respect to the control methodology of CFRP primary structures in manned space flight and the implications to the design, analysis and testing of CFRP structural elements, executive summary
[MBB-TR-RB517-014/85] p 97 N88-16824
In-orbit automatic assembly of reticular structures p 92 N88-19491

SPACECRAFT SURVIVABILITY
Spacecraft fire detection and extinguishment: A bibliography
[NASA-CR-180880] p 158 N88-18612

SPACECRAFT TEMPERATURE
Preliminary design of the Space Station internal thermal control system
[SAE PAPER 871505] p 35 A88-21151
Design of an ammonia two-phase Prototype Thermal Bus for Space Station
[SAE PAPER 871506] p 35 A88-21152
The Spacehab module passive thermal control
[SAE PAPER 871508] p 35 A88-21154
The effect of maximum-allowable payload temperature on the mass of a multimegawatt space-based platform
[DE88-001921] p 37 N88-13381
EUREX D: An expert system for failure diagnosis and recovery in the TCS of the European retrievable carrier EURECA p 146 N88-16385

SPACECRAFT TRACKING
Spacecraft 2000
[NASA-CP-2473] p 106 N88-10084

SPACECRAFT TRAJECTORIES
Safe and fuel minimum reference trajectories for closed loop controlled approaches — space stations p 61 N88-19488

SPACECREWS
The role of psychologists in future spaceflight p 159 A88-10958
Technology advancements to improve crew productivity in space p 151 A88-15283
Orbit design for a space ambulance vehicle p 149 A88-15313
Small groups in orbit - Group interaction and crew performance on Space Station p 151 A88-15348
Crew productivity issues in long-duration space flight
[AIAA PAPER 88-0444] p 154 A88-22330
Cosmonauts observe supernova p 144 A88-30188
An assessment of clinical chemical sensing technology for potential use in space station health maintenance facility
[NASA-CR-172013] p 156 N88-12926

SPACELAB
Spacehab - A manned Space Station testbed p 103 A88-15267
A Pallet-based space program for Australia p 122 A88-15521
Absorptive tethers - A first test in space p 115 A88-27781
Space Station Mission Planning System (MPS) development study. Volume 1: Executive summary
[NASA-CR-179202] p 4 N88-10047
Allowable gravity-levels for Spacelab, Columbus and EURECA — materials science
[BF-R-66.525-2] p 132 N88-15084
Project management in astronautics: From Spacelab to Columbus
[MBB-URE-943/87] p 167 N88-17858
Implications of shiftwork in space for human physiology experiments p 129 N88-19942
Microgravity User Support Center (MUSC) for EURECA, Spacelab and Columbus missions p 149 N88-19947

SPACELAB PAYLOADS
Evolution of data management systems from Spacelab to Columbus
[MBB-UR-E-WA-87] p 99 A88-23981
Space Station Mission Planning System (MPS) development study. Volume 2
[NASA-CR-179200] p 4 N88-10048

SPECIMENS
Method of radiographic inspection of wooden members
[NASA-CASE-LAR-13724-1] p 149 N88-23983

SPECKLE PATTERNS
ISIS: Imaging Speckle Interferometer in Space p 116 N88-10625

SPECTROGRAPHS
AURIO: A proposal for flying auroral imaging observatory on the Polar Platform in the Space Station/Columbus program p 119 N88-16268

SPECTROMETERS
Commercial perspective of an imaging spectrometer development program p 165 N88-12138
Astromag: A particle spectrometer for the Space Station
[PREPRINT-557] p 118 N88-14336

SPEECH RECOGNITION
National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 1
[NASA-CR-172009-VOL-1] p 166 N88-14855

SPOT (FRENCH SATELLITE)
SPOT 1 - Earth observing satellite p 3 A88-26166

216

SPRAYING
Fire extinguishment and inhibition in spacecraft environments p 156 N88-12523
SPRINGS (ELASTIC)
The nonlinear behavior of a passive zero-spring-rate suspension system
[AIAA PAPER 88-2316] p 57 A88-32264
STABILITY
Computational methods for problems in aerodynamics and large space structure using parallel and vector architectures
[AD-A185401] p 27 N88-13294
Preliminary investigation of stability of a tri-stiffened slender strut
[NASA-TM-4034] p 31 N88-19568
STANDARDIZATION
NASA-STD-3000, Man-System Integration Standards - The new space human engineering standards
[IAF PAPER 87-552] p 152 A88-16167
STANDARDS
Fire-related standards and testing
p 156 N88-12522
NASA/NBS (National Aeronautics and Space Administration/National Bureau of Standards) standard reference model for Telerobot Control System Architecture (NASREM)
[PB88-124773] p 92 N88-17999
STAPHYLOCOCCUS
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment
p 145 N88-12917
STATE ESTIMATION
An experimental study on flexible spacecraft three-axis attitude control p 53 A88-26356
On local state feedback and stability domain estimation of nonlinear large scale systems p 144 A88-29245
STATE VECTORS
Teleoperator and robotics system analysis
[NASA-CR-179220] p 67 N88-12105
STATIONARY ORBITS
A composite structural system for a large collapsible space antenna p 19 A88-31403
STATIONKEEPING
Solar sails and the Arsat satellite - Scientific applications and techniques p 106 A88-28864
Phase 3 study of selected tether applications in space. Volume 2: Study results
[NASA-CR-179186] p 116 N88-10828
STATORS
Computer-aided modeling and prediction of performance of the modified Lundell class of alternators in space station solar dynamic power systems
[NASA-CR-182539] p 74 N88-19000
STEADY STATE
Steady state micro-g environment on Space Station
[AIAA PAPER 88-2462] p 4 A88-31385
Active vibration control in microgravity environment
p 55 A88-31565
STEAM
Stability of IRA-45 solid amine resin as a function of carbon dioxide absorption and steam desorption cycling
[SAE PAPER 871452] p 40 A88-21112
STELLAR EVOLUTION
Physics and chemistry p 118 N88-15359
STIFFENING
Preliminary investigation of stability of a tri-stiffened slender strut
[NASA-TM-4034] p 31 N88-19568
STIFFNESS
Monitoring elastic stiffness degradation in graphite/epoxy composites p 14 A88-18173
STIFFNESS MATRIX
Recent advances in dynamics of composite structures
p 19 A88-31427
Optimal reconfiguration of thermally distorted wire mesh reflectors for large space antennas
[AIAA PAPER 88-2340] p 22 A88-32283
Structural model verification with LQG theory — Linear Quadratic Optimization
[AIAA PAPER 88-2360] p 23 A88-32300
STIMULATION
Advancing automation and robotics technology for the space station and for the US economy. Submitted to the United States Congress October 1, 1986
[NASA-TM-89190] p 89 N88-15818
STIRLING CYCLE
Advanced space solar dynamic power systems beyond IOC Space Station p 64 A88-11798
STIRLING ENGINES
Ross-Stirling engine - A high performance dynamic space power system p 63 A88-11797
STOCHASTIC PROCESSES
Optimal on-line measurement system configuration strategies
[AIAA PAPER 88-2341] p 8 A88-32284
Stochastic model of the NASA/MSFC ground facility for large space structures with uncertain parameters. The maximum entropy approach
[NASA-CR-181489] p 27 N88-12343
STORAGE TANKS
Orbital Spacecraft Consumables Resupply System (OSCRS). Volume 2: Study results
[NASA-CR-172011] p 126 N88-11687
Space environmental considerations for a long-term cryogenic storage vessel p 80 N88-15933
STRAIN GAGES
Control of gripper position of a compliant link using strain gauge measurements p 48 A88-14995
STRATEGY
Investigation of design concepts for large space structures to support military applications
[AD-A186098] p 29 N88-15000
State-of-the-art technologies for construction in space: A review
[AD-A188412] p 31 N88-19483
STRATOSPHERE
Stratospheric luminescence observed from the Salyut-7 station p 144 A88-30076
STRESS ANALYSIS
Stress and deformation analysis and tests of composite structures for space application
[IAF PAPER 87-312] p 12 A88-16011
STRESS DISTRIBUTION
Wave propagation experiments on 22-bay lattice
[AD-A186140] p 29 N88-15002
STRESS FUNCTIONS
Dispersion, damping and confinement of propagating pulses in large space structures
[AIAA PAPER 88-2311] p 22 A88-32259
STRESS WAVES
Active modification of wave reflection and transmission in flexible structures p 16 A88-27395
Dispersion, damping and confinement of propagating pulses in large space structures
[AIAA PAPER 88-2311] p 22 A88-32259
STRUCTURAL ANALYSIS
Optimum design of structures with multiple constraints
p 16 A88-29042
Structural testing on the multi-axis simulator - An innovative simulation system for space-vehicle structures
p 17 A88-29725
AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers p 17 A88-31376
Structural assessment of a Space Station solar dynamic heat receiver thermal energy storage canister
[AIAA PAPER 88-2467] p 72 A88-31396
Solution of structural analysis problems on a parallel computer
[AIAA PAPER 88-2267] p 22 A88-32240
Assessment of the COFS/MAST I project
[NASA-CR-181366] p 25 N88-10340
Space station systems: A bibliography with indexes
[NASA-SP-7056(05)] p 5 N88-13382
Simultaneous structural and control optimization via linear quadratic regulator eigenstructure assignment
p 28 N88-13622
Continuum modeling of large lattice structures: Status and projections
[NASA-TP-2767] p 29 N88-14115
Natural frequencies and structural integrity assessment of large space structures
[AD-A186139] p 29 N88-15001
Analytical interactive approach for phenomena involving structures, thermal and control aspects. Volume 1: Theory — spacecraft structures
[ESA-CR(P)-2503-VOL-1] p 60 N88-16803
Analytical interactive approach for phenomena involving structures, thermal, and control aspects. Volume 2: Toward the solution — spacecraft structures
[ESA-CR(P)-2503-VOL-2] p 60 N88-16804
Analytical interactive approach for phenomena involving structures, thermal, and control aspects. Volume 3: Executive summary — spacecraft structures
[ESA-CR(P)-2503-VOL-3] p 60 N88-16805
STRUCTURAL DESIGN
Space Station electric power system requirements and design p 63 A88-11782
Structural design and decoupled control — of large space structures
[IAF PAPER 87-318] p 48 A88-16016
Capabilities and special features concerning structural optimization of spacecraft structures
[IAF PAPER 87-320] p 12 A88-16018
Sensitivity analysis and optimal design for large unrestrained structures
[IAF PAPER 87-321] p 12 A88-16019
Optimum design of structures with multiple constraints
p 16 A88-29042
Large space structures - Structural concepts and materials
[SAE PAPER 872429] p 17 A88-30999
Structural tailoring and feedback control synthesis - An interdisciplinary approach
[AIAA PAPER 88-2206] p 21 A88-32177
Bragov commentary on Mir station, first manning
p 144 N88-10061
Space station integrated wall design and penetration damage control
[NASA-CR-179169] p 25 N88-10070
Telepresence work station system definition study, part 2
[NASA-CR-172006] p 4 N88-10071
Space station propulsion technology: Space station propulsion system test bed test plan
[NASA-CR-179201] p 78 N88-10104
Phase 3 study of selected tether applications in space. Volume 2: Study results
[NASA-CR-179186] p 116 N88-10828
Design and assembly sequence analysis of option 3 for CETF reference space station
[NASA-TM-100503] p 126 N88-13369
Space station systems: A bibliography with indexes
[NASA-SP-7056(05)] p 5 N88-13382
The high performance solar array GSRG
[SNIAS-872-422-108] p 73 N88-13814
Integrity control of carbon fiber reinforced plastics (CFRP) structural elements. Conclusion with respect to the control methodology of CFRP primary structures in manned space flight and the implications to the design, analysis and testing of CFRP structural elements, executive summary
[MBB-TR-RB517-014/85] p 97 N88-16824
Automatic in-orbit payload deployment mechanisms, logistic operations and transport vehicle design compatibilities p 92 N88-19493
Progress toward a cosmic dust collection facility on space station
[NASA-CR-182427] p 121 N88-19566
Conceptual design and programmatics studies of space station accommodations for Life Sciences Research Facilities (LSRF)
[NASA-CR-179270] p 46 N88-19567
Space station accommodations for life sciences research facilities. Phase A conceptual design and programmatics studies for Missions SAAX0307, SAAX0302 and the transition from SAAX0307 to SAAX0302. Volume 1: Executive summary
[NASA-CR-179267] p 104 N88-19571
STRUCTURAL DESIGN CRITERIA
Optimization of the energy systems of manned orbital stations - Mathematical modeling and selection of efficient structures — Russian book p 68 A88-15864
Recent advances in structural dynamics of large space structures
[IAF PAPER 87-51] p 11 A88-15838
A criterion for shape control robustness of space structures p 16 A88-29720
An efficient multilevel optimization method for engineering design
[AIAA PAPER 88-2226] p 8 A88-32190
Simultaneous structural and control optimization via linear quadratic regulator eigenstructure assignment
p 28 N88-13622
STRUCTURAL ENGINEERING
Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Parts 1, 2, & 3 p 21 A88-32176
An efficient multilevel optimization method for engineering design
[AIAA PAPER 88-2226] p 8 A88-32190
Efficient placement of structural dynamics sensors on the space station
[NASA-CR-172015] p 25 N88-10103
STRUCTURAL FAILURE
Natural frequencies and structural integrity assessment of large space structures
[AD-A186139] p 29 N88-15001
STRUCTURAL MEMBERS
Control-augmented structural synthesis
[AIAA PAPER 88-1014] p 55 A88-28043
Potential for on-orbit manufacture of large space structures using the pultrusion process
[NASA-TM-4016] p 29 N88-13368
Chromic acid anodizing of aluminum foil
[NASA-CR-179417] p 97 N88-15077
STRUCTURAL RELIABILITY
Integrity control of carbon fiber reinforced plastics (CFRP) structural elements. Conclusion with respect to the control methodology of CFRP primary structures in manned space flight and the implications to the design, analysis and testing of CFRP structural elements, executive summary
[MBB-TR-RB517-014/85] p 97 N88-16824

STRUCTURAL STABILITY
Protective coatings for composite tubes in space applications p 94 A88-13239
Spillover stabilization of large space structures [AIAA PAPER 88-2484] p 55 A88-31393

STRUCTURAL VIBRATION
Development of the Mast Flight System linear dc motor inertial actuator [AAS PAPER 87-221] p 13 A88-16990
Low authority-threshold control for large flexible structures [AIAA PAPER 88-2270] p 22 A88-32226
Three parallel computation methods for structural vibration analysis [AIAA PAPER 88-2391] p 24 A88-32323
Passive damping for space truss structures [AIAA PAPER 88-2469] p 24 A88-32360
Simultaneous structural and control optimization via linear quadratic regulator eigenstructure assignment p 28 N88-13622
Viscous damped space structure for reduced jitter p 28 N88-13623

STRUCTURAL WEIGHT
Optimization of actively controlled structures using goal programming techniques p 53 A88-25797

STRUTS
Preliminary investigation of stability of a fin-stiffened slender strut [NASA-TM-4034] p 31 N88-19568

SUBSTRUCTURES
Verification of large beam-type space structures p 14 A88-18637
Experimental component mode synthesis of structures with sloppy joints [AIAA PAPER 88-2411] p 24 A88-32339

SUNLIGHT
Sunlight supply and gas exchange systems in microalgal bioreactor p 44 N88-12258

SUPERCOMPUTERS
Report from the MPP Working Group to the NASA Associate Administrator for Space Science and Applications [NASA-TM-87819] p 100 N88-11402

SUPERCONDUCTING MAGNETS
Astromag: A particle spectrometer for the Space Station [PREPRINT-557] p 118 N88-14336

SUPERHIGH FREQUENCIES
X-band SAR for a European remote sensing payload p 117 N88-12142

SUPERNOVA 1987A
Cosmonauts observe supernova p 144 A88-30169

SUPERSONIC FLOW
Raman spectra of adsorbed layers on space shuttle and AOTV thermal protection system surface p 132 N88-14890

SUPPLYING
Prototype resupply scheduler p 9 N88-16424

SUPPORT SYSTEMS
Space station accommodations for lunar base elements: A study [NASA-TM-100501] p 106 N88-14907
A space transportation system operations model [NASA-TM-100481] p 8 N88-14999

SURFACE DISTORTION
Compensation of reflector antenna surface distortion using an array feed [NASA-TM-100286] p 77 N88-19805

SURFACE GEOMETRY
Research and development of the tension truss antenna [IAF PAPER 87-317] p 12 A88-16015

SURFACE REACTIONS
Spacecraft surface exposure to atomic oxygen in low Earth orbit p 96 N88-11715

SURVIVAL
The determination of nutritional requirements for Safe Haven Food Supply System (emergency/survival foods) p 45 N88-14856

SUSPENSION SYSTEMS (VEHICLES)
The nonlinear behavior of a passive zero-spring-rate suspension system [AIAA PAPER 88-2316] p 57 A88-32264

SWATH WIDTH
Swath altimetry of oceans and terrain p 115 A88-27838

SWITCHING
Automatic antenna switching design for Extra Vehicular Activity (EVA) communication system p 77 N88-14983

SYMBOLIC PROGRAMMING
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems [NASA-TM-89705] p 88 N88-15497

SYNCHRONOUS PLATFORMS
Communications payload concepts for geostationary facilities [NASA-TM-100154] p 76 N88-13513
Coorbiting Platform Utilization Study (CPLUS), executive summary — Columbus [SN-WP-4000-DOC-6809/85/F] p 120 N88-16768

SYNCHRONOUS SATELLITES
Challenge '96 - The Ariane 5 Development Programme [IAF PAPER 87-185] p 137 A88-15826
Development of on-board satellite communications equipment in the Geostationary Platform era [IAF PAPER 87-495] p 110 A88-16136
Automatic control in space 1985 p 50 A88-16276
Solar sailing attitude control of large geostationary satellite p 50 A88-16280
Evaluation of control concepts for a large geostationary data relay satellite p 50 A88-16281
The Spacebus platforms [AIAA PAPER 88-0775] p 115 A88-27535
Japan takes charge p 143 A88-27952
Satellite assembly in geostationary orbit: A plug-and-socket concept p 127 N88-16769

SYNTHETIC APERTURE RADAR
A near field test system for very large antennas p 13 A88-17589
Study of a payload for Columbus Polar Platform Earth observation demonstration mission, executive summary [ESA-CR(P)-2412] p 116 N88-10079
X-band SAR for a European remote sensing payload p 117 N88-12142

SYNTHETIC RESINS
Stability of IRA-45 solid amine resin as a function of carbon dioxide absorption and steam desorption cycling [SAE PAPER 871452] p 40 A88-21112

SYSTEM FAILURES
Use of communicating expert systems in fault diagnosis for Space Station applications p 43 A88-21835

SYSTEM IDENTIFICATION
Recent advances in structural dynamics of large space structures [IAF PAPER 87-51] p 11 A88-15836
Estimation and identification of nonlinear dynamic systems [AIAA PAPER 88-2271] p 57 A88-32227
Mode shape identification and orthogonalization [AIAA PAPER 88-2354] p 23 A88-32294
System identification of flexible structures [AIAA PAPER 88-2361] p 23 A88-32301

SYSTEMS ANALYSIS
Status of the Space Station water reclamation and management subsystem design concept [SAE PAPER 871510] p 42 A88-21156
An approach to design knowledge capture for the space station p 7 A88-21642
Simple analysis of Space Station downlinks p 100 A88-30189
Spacecraft 2000 [NASA-CP-2473] p 106 N88-10084
Space Assembly, Maintenance, and Servicing Study (SAMSS) p 125 N88-10089
Spacecraft Systems Working Group report p 165 N88-10091
Recent advances in structural dynamics of large space structures [NASA-TM-100513] p 26 N88-10867
Controlled Ecological Life Support Systems (CELSS) physicochemical waste management systems evaluation [NASA-CR-177422] p 45 N88-14626
Orbital transfer vehicle studies overview p 150 N88-15931
Orbiter transfer vehicle concept definition and system analysis study. Volume 4: Space station accommodations. Revision 1 [NASA-CR-179293] p 150 N88-18609
Orbital transfer vehicle concept definition and system analysis study. Volume 4, Appendix A: Space station accommodations. Revision 1 [NASA-CR-179294] p 150 N88-18610
Space station operating system study [NASA-CR-179308] p 127 N88-18619
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 2: OSSA integrated logistics support strategy p 8 N88-19479
Motion simulation for in-orbit operations p 62 N88-19514

SYSTEMS COMPATIBILITY
Interoperability and integration of data relay satellite systems p 76 N88-12134

SYSTEMS ENGINEERING
Radiator selection for Space Station Solar Dynamic Power Systems p 32 A88-11806
A systems engineering approach to automated failure cause diagnosis in space power systems p 68 A88-11970
A research laboratory in space [IAF PAPER 87-60] p 161 A88-15840
The Columbus space segment [IAF PAPER 87-66] p 136 A88-15845
The Aerosseist Flight Experiment [IAF PAPER 87-197] p 2 A88-15924
Electrical current flow across the TSS - The core equipment and other related technical issues [IAF PAPER 87-252] p 109 A88-15971
Orbital Maneuvering Vehicle (OMV) propulsion subsystem [IAF PAPER 87-261] p 149 A88-15978
Aeroassisted vehicle design studies for a manned Mars mission [IAF PAPER 87-433] p 50 A88-16093
A computer aided engineering tool for ECLS systems [SAE PAPER 871423] p 98 A88-21087
Columbus operation and utilization p 141 A88-21563
Automated Space Station procedure execution [AIAA PAPER 88-0443] p 99 A88-22329
Space erectable radiator system development [AIAA PAPER 88-0469] p 36 A88-22345
1987 American Control Conference, 6th, Minneapolis, MN, June 10-12, 1987, Proceedings. Volumes 1, 2, & 3 p 53 A88-27301
Prephase A study of a crystallization laboratory for Columbus, executive summary [ESA-ITT/AO/1-1866/85/F] p 96 N88-10206
Robotic sensors and actuators for a service manipulator system. Volume 2: Service Manipulator System (SMS) handbook [MATRA-EPT/DT/vT187/227] p 87 N88-10342
A preliminary study of a fluid science laboratory for space station (Columbus). Part 4: Executive summary [NLR-TR-87023-L/PT-4] p 79 N88-11072
Pinhole occulter experiment [NASA-CR-179206] p 116 N88-11481
Carbon Dioxide observational platform system (CO-OPS) Feasibility Study [NASA-CR-179225] p 118 N88-14113
Docking/Berthing Subsystem (DBS). Development part 1: Latching analysis — Columbus [ESA-CR(P)-2479] p 60 N88-15825
JPRS report: Science and technology. USSR: Space [JPRS-USP-87-006] p 146 N88-16063
FMEAssist: A knowledge-based approach to Failure Modes and Effects Analysis p 101 N88-16395
Knowledge-based simulation p 102 N88-16404
Columbus feasibility studies. Volume 2: Element constituents, mechanical [ETN-88-91074] p 146 N88-16800
Columbus feasibility studies. Volume 3: Avionics, systems [ETN-88-91075] p 148 N88-16801
Design knowledge capture for the space station p 9 N88-17239
Development of the Extendable and Retractable Mast (ERM). Design phase 2. Volume 1 — spacecraft payloads [RP-2010-0000-DS/09] p 31 N88-18750

SYSTEMS INTEGRATION
Integrated heat pipe-thermal storage system performance evaluation p 32 A88-11803
An integrated approach to space station power system autonomous control p 67 A88-11853
Automated testing and integration of heterogeneous systems — for Space Station power management p 33 A88-11874
Aspects and possibilities of an integrated energy and media supply system on H2/O2-basis for manned space stations in the low earth orbit [IAF PAPER 87-241] p 38 A88-15963
The Columbus Attached Pressurized Module - System and management aspects of international cooperation p 139 A88-21252
Use of communicating expert systems in fault diagnosis for Space Station applications p 43 A88-21835
Applying technology to systems; Aerospace Computer Security Conference, 3rd, Orlando, FL, Dec. 7-11, 1987, Technical Papers p 8 A88-26206
Space station integrated propulsion and fluid system study: Fluid systems configuration databook [NASA-CR-179215] p 79 N88-11753
Carbon Dioxide observational platform system (CO-OPS) Feasibility Study [NASA-CR-179225] p 118 N88-14113
Development of a graphical display on the DMS test bed p 101 N88-14864
Space station software reliability analysis based on failures observed during testing at the multisystem integration facility p 101 N88-14884
Servicer system demonstration plan and capability development [NASA-CR-179248] p 127 N88-15896

218

Columbus feasibility studies. Volume 4: Integration, test, and operations
[ETN-88-90576] p 147 N88-18614

SYSTEMS MANAGEMENT
Assembling, maintaining and servicing Space Station
[IAF PAPER 87-85] p 123 A88-15859
The distributed AI system for the dynamic allocation and management of power (DAISY-DAMP) testbed
p 84 A88-21638
Autonomous management of the Space Station electric energy system p 71 A88-21641
Automated Space Station procedure execution
[AIAA PAPER 88-0443] p 99 A88-22329
Critical issues for establishment of a permanently-occupied lunar base
[AD-A187128] p 107 N88-17567

SYSTEMS SIMULATION
Solar dynamic organic Rankine cycle heat rejection system simulation p 65 A88-11808
Computer modeling and simulation of a 20kHz ac distribution system for Space Station p 66 A88-11827
Columbus Simulation Facility (CSF)
p 148 N88-19522
A comparative survey of mathematical models for dynamic simulation of in-orbit manipulation operations
p 148 N88-19533

SYSTEMS STABILITY
Robust stabilization under mode truncation and parameter variations p 15 A88-27325
On local state feedback and stability domain estimation of nonlinear large scale systems p 144 A88-29245

T

TASKS
Task-level robot programming: Integral part of evolution from teleoperation to autonomy p 91 N88-17279

TDR SATELLITES
Interoperability and integration of data relay satellite systems p 76 N88-12134

TEAMS
The Soviet cosmonaut team, 1978-1987
p 144 A88-30185

TECHNICAL WRITING
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 3: OSSA integrated logistics support planning document p 6 N88-12480

TECHNOLOGICAL FORECASTING
Looking to year 2001 p 104 A88-13974
Future European ground segment — to support earth observation satellites p 133 A88-15279
Rendezvous and docking technology for future European missions p 48 A88-15280
Commercial launch systems - The foreseeable future for Aussat p 161 A88-15480
Laser solar power satellites - A case study in technology forecasting p 68 A88-15492
Potentials of robotic operations on board the man-tended free-flyer
[IAF PAPER 87-17] p 82 A88-15813
Orbital Maneuvering Vehicle - New capability
[IAF PAPER 87-194] p 149 A88-15931
The space based OTV and the establishment of the next launch site
[IAF PAPER 87-196] p 149 A88-15933
Earth science missions for the Space Station
p 111 A88-17039
Japan - Future space samurai? p 139 A88-18223
Biotechnology opportunities on Space Station
[SAE PAPER 871468] p 154 A88-21124
New radiator system designed for large spacecraft
p 36 A88-25368
A 50 year scenario for the utilization of space to improve the quality-of-life on earth p 164 A88-27658
Spacecraft 2000 program overview
p 165 N88-10085
Attitude Control Working Group report
p 57 N88-10099

TECHNOLOGY ASSESSMENT
Space Congress, 24th, Cocoa Beach, FL, Apr. 21-24, 1987, Proceedings p 161 A88-15276
The in-orbit technology demonstration programme of the European Space Agency
[IAF PAPER 87-03] p 135 A88-15803
Spacecraft technology trends - A view from the past
[IAF PAPER 87-07] p 161 A88-15807
Technology - The basis for the past, the key to the future
[IAF PAPER 87-47] p 161 A88-15833
Recent advances in structural dynamics of large space structures
[IAF PAPER 87-51] p 11 A88-15836
The evolution of space power systems technology
[IAF PAPER 87-226] p 68 A88-15952
Soyuz enters third decade p 138 A88-16700
Spacecraft water system disinfection technology - Past, present, and future needs
[SAE PAPER 871487] p 41 A88-21141
Status of the Space Station water reclamation and management subsystem design concept
[SAE PAPER 871510] p 42 A88-21156
Human exploration of Mars — assessment of technology requirements
[AIAA PAPER 88-0064] p 105 A88-22044
Techniques for assessment of flexible space structure control performance
[AIAA PAPER 88-0677] p 52 A88-22507
Spaceward ho — U.S. and Soviet space programs
[AIAA PAPER 88-0750] p 163 A88-22567
Spacecraft 2000 program overview
p 165 N88-10085
Communication satellite technology trends
p 76 N88-10088
Spacecraft Systems Working Group report
p 165 N88-10091
Attitude Control Working Group report
p 57 N88-10099
Space technology to meet future needs
[NASA-CR-181473] p 106 N88-10819
Potential applications of expert systems and operations research to space station logistics functions
[NASA-CR-180473] p 87 N88-12342
Advancing automation and robotics technology for the space station and for the US economy. Submitted to the United States Congress May 15, 1987
[NASA-TM-89911] p 88 N88-15817
Advancing automation and robotics technology for the space station and for the US economy. Submitted to the United States Congress October 1, 1986
[NASA-TM-89190] p 89 N88-15818
Satellite power systems under consideration by the United Nations p 74 N88-16773
Remote manipulation in orbital construction, servicing and repair missions: Is one arm enough? A comparative evaluation of the performance features of robots with one or more arms p 93 N88-19509
Robotics servicing experiment — European space programs p 93 N88-19529
Technology requirements for telerobotic satellite servicing in space p 93 N88-19536
Space station accommodations for life sciences research facilities. Phase A: conceptual design and programmatics studies for Missions SAAX0307, SAAX0302 and the transition from SAAX0307 to SAAX0302. Volume 1: Executive summary
[NASA-CR-179267] p 104 N88-19571
Workshop on Technology Development Issues for the Large Deployable Reflector (LDR)
[NASA-CP-2407] p 32 N88-20235

TECHNOLOGY FEASIBILITY SPACECRAFT
Solar sails and the Ansat satellite - Scientific applications and techniques p 106 A88-29864

TECHNOLOGY UTILIZATION
Technology advancements to improve crew productivity in space p 151 A88-15283
Preparation of Space Station/Columbus utilization
[IAF PAPER 87-95] p 137 A88-15866
Static feed electrolyzer technology advancement for space application
[SAE PAPER 871450] p 40 A88-21110
Columbus operation and utilization
p 101 A88-21563
Columbus utilization preparation - Status of ongoing studies p 141 A88-21565
Science on Space Station p 2 A88-21566
Space science with Columbus p 141 A88-21567
Tethers in space - A broad perspective
[AIAA PAPER 88-0530] p 113 A88-22396
Man Tended Free Flyer utilization aspects
[MBB-UR-E-981-87] p 142 A88-23991
Space station: Leadership for the future
[NASA-PAM-509/9-87] p 165 N88-10072
Spacecraft 2000 program overview
p 165 N88-10085
Space station platforms p 116 N88-10086
Space station based interferometry
p 116 N88-10628
Columbus pressurized module utilization study, executive summary
[CS-RP-AI-027] p 146 N88-15005
The NORSTAR Program: Space shuttle to space station p 167 N88-17710
Utilization of robotics and teleoperation for future in-orbit operations p 93 N88-19527

TELECOMMUNICATION
Telescience testbedding for life science missions on the Space Station
[AIAA PAPER 88-0446] p 86 A88-22332

TELEMETRY
The use of transputers in processing telemetry data
p 96 A88-15303
Spacecraft 2000
[NASA-CP-2473] p 106 N88-10054

TELEOPERATORS
Semiautonomous control for satellite servicing
[AIAA PAPER 87-2952] p 81 A88-12573
On the modeling and control of a flexible manipulator arm by point actuators p 82 A88-14996
Control of in-orbit space manipulation
p 51 A88-16312
Stability analysis for alternative force control schemes as applied to remote space teleoperation
[AAS PAPER 87-043] p 51 A88-16998
Space telerobotics technology demonstration program
[AAS PAPER 87-045] p 84 A88-17000
The use of computer graphic simulation in the development of on-orbit tele-robotic systems
p 85 A88-21646
An orbiting control station for free-flying teleoperators - Preliminary design methodology p 51 A88-21647
System architecture for telerobotic servicing and assembly tasks p 85 A88-21649
Computing architecture for telerobots in earth orbit
p 99 A88-21650
The NASA telerobot technology demonstrator
p 85 A88-21651
Development of a master slave manipulator system for space use p 96 A88-26975
Telepresence work station system definition study, part 2
[NASA-CR-172006] p 4 N88-10071
Telerobotics p 86 N88-10090
Robotic sensors and actuators for a service manipulator system. Volume 3, phase A report and program plan
[MATRA-EPT/DT/VT187/228] p 87 N88-10343
Traction-drive seven degrees-of-freedom telerobot arm: A concept for manipulation in space
[DE87-010895] p 87 N88-10346
Teleoperation and control study — orbital servicing
[BAE-TP-8268] p 87 N88-10489
Teleoperator and robotics system analysis
[NASA-CR-179220] p 87 N88-12105
Telerobotic controller development p 89 N88-16370
Manipulator arm design for the Extravehicular Teleoperator Assist Robot (ETAR) Applications on the space station p 91 N88-17270
Crew interface with a telerobotic control station
p 91 N88-17273
NASA/NBS (National Aeronautics and Space Administration/National Bureau of Standards) standard reference model for Telerobot Control System Architecture (NASREM)
[PB88-124773] p 92 N88-17999
Technology requirements for telerobotic satellite servicing in space p 93 N88-19536
A teleoperated manipulator system concept for unmanned platforms — Columbus p 94 N88-19537

TELESCOPES
An advanced imaging space telescope concept
[IAF PAPER 87-460] p 110 A88-16113

TEMPERATURE
Estimating payload internal temperatures and radiator size for multimegawatt space platforms
[DE88-000244] p 37 N88-11738

TEMPERATURE CONTROL
On the hierarchical control of the Space Station common module thermal system p 33 A88-14980
ITDS - A program for interactive design and analysis of advanced active thermal control systems
[SAE PAPER 871421] p 34 A88-21085
Environmental control and life support system for Japanese Experiment Module
[SAE PAPER 871429] p 39 A88-21092
Thermal control definition of Columbus pressurized modules
[SAE PAPER 871483] p 139 A88-21138
Preliminary design of the Space Station internal thermal control system
[SAE PAPER 871505] p 35 A88-21151
Design of an ammonia two-phase Prototype Thermal Bus for Space Station
[SAE PAPER 871506] p 35 A88-21152
The Spacehab module passive thermal control
[SAE PAPER 871508] p 35 A88-21154
Thermal contact conductance in the presence of thin metal foils
[AIAA PAPER 88-0466] p 35 A88-22342
Space Station Active Thermal Control System modeling
[AIAA PAPER 88-0473] p 36 A88-22349
Thermal environment simulator for vacuum testing of large spacecraft p 36 A88-25879
Thermal Control Working Group report
p 36 N88-10094

Considerations concerning a thermal joint for a deployable or steerable battery radiator for the Columbus Polar Platform
[NLR-TR-86055-U] p 37 N88-11739
Development of an emulation-simulation thermal control model for space station application
[NASA-CR-182409] p 37 N88-15823
Thermal structural control modeling techniques — spacecraft
[FOK-TR-R-86-030] p 38 N88-15828
MTK: An AI tool for model-based reasoning
p 9 N88-16372
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems
p 89 N88-16373
EUREX D: An expert system for failure diagnosis and recovery in the TCS of the European retrievable carrier EURECA p 146 N88-16385
Analytical interactive approach for phenomena involving structures, thermal and control aspects. Volume 1: Theory — spacecraft structures
[ESA-CR(P)-2503-VOL-1] p 60 N88-16803
Analytical interactive approach for phenomena involving structures, thermal, and control aspects. Volume 2: Toward the solution — spacecraft structures
[ESA-CR(P)-2503-VOL-2] p 60 N88-16804
Analytical interactive approach for phenomena involving structures, thermal, and control aspects. Volume 3: Executive summary — spacecraft structures
[ESA-CR(P)-2503-VOL-3] p 60 N88-16805
TDAS: The Thermal Expert System (TEXSYS) data acquisition system p 102 N88-17258

TEMPERATURE DEPENDENCE
Ignition and combustion of metals in oxygen
p 79 N88-12530

TEMPERATURE DISTRIBUTION
Large deployable reflector thermal characteristics in low earth orbits
[AIAA PAPER 88-0471] p 36 A88-22347

TENSILE PROPERTIES
Carbon fiber reinforced glass matrix composites for space based applications
[AD-A184355] p 96 N88-12548

TENSILE STRESS
Comparison of experimental techniques in the measurement of damping capacity of metal-matrix composites p 56 A88-31600

TEST EQUIPMENT
Telescience testbedding for life science missions on the Space Station
[AIAA PAPER 88-0446] p 86 A88-22332
Space station propulsion technology
[NASA-CR-179260] p 80 N88-15835
Simulation test beds for the space station electrical power system
[NASA-TM-100786] p 74 N88-17715
Construction aspects of testbeds for attitude control systems simulation of artificial satellites
[INPE-4283-PRE/1155] p 61 N88-18616

TEST FACILITIES
Research opportunities in microgravity science and applications during Shuttle hiatus p 108 A88-13184
Large space structures testing
[AAS PAPER 87-036] p 13 A88-16996
Structural testing on the multi-axis simulator - An innovative simulation system for space-vehicle structures
p 17 A88-29725
EPOS - A facility for simulating operations near spacecraft p 56 A88-32145
Fourteenth Space Simulation Conference: Testing for a Permanent Presence in Space
[NASA-CP-2446] p 5 N88-10829
High intensity 5 eV O-atom exposure facility for material degradation studies p 96 N88-10847
The ac power system testbed
[NASA-CR-175066] p 72 N88-11948
Feasibility study for gas-grain simulation facility
[NASA-CR-177466] p 28 N88-13954
NASDA's new test facilities for satellites and rockets
p 147 N88-18951
Cost effective development of a national test bed
[NASA-TM-100321] p 31 N88-19585

TESTS
Fire-related standards and testing
p 156 N88-12522

TETHERED SATELLITES
Stability of the steady motions of an electromagnetic tether system in orbit p 107 A88-11234
Tethered space elevator - Possible applications and demonstrative experiments
[IAF PAPER 87-49] p 109 A88-15834
Electrical current flow across the TSS - The core equipment and other related technical issues
[IAF PAPER 87-252] p 109 A88-15971
Dynamics and control of the tethered satellite system in the presence of offsets
[IAF PAPER 87-316] p 109 A88-16014
Fault tolerant onboard implementation of control procedures in tethered satellite p 110 A88-16285
On control of tethered satellite systems
p 110 A88-16294
Tethered space system - A new facility for experimental rarefied gas dynamics p 111 A88-16858
Low density aerothermodynamics studies performed by means of the tethered satellite system
p 111 A88-16859
Feasibility study of a stabilizer fin for the tethered satellite system p 111 A88-16860
Results from a series of tethered rocket experiments
p 111 A88-18634
Dynamics and control of the Tethered Satellite System in the presence of offsets p 112 A88-20036
Recent developments in gravity gradiometry from the Space-Shuttle-borne tethered satellite system
p 112 A88-21531
Tethers in space - A broad perspective
[AIAA PAPER 88-0530] p 113 A88-22396
Tether Dynamics Simulation Workshop summary
[AIAA PAPER 88-0531] p 113 A88-22397
Tether technology - Conference summary
[AIAA PAPER 88-0533] p 113 A88-22398
Tethers on stations and platforms
[AIAA PAPER 88-0534] p 113 A88-22399
Comments on the 'early experimental validation' session of the Second International Conference on Tethers in Space
[AIAA PAPER 88-0535] p 113 A88-22400
Outer atmospheric research
[AIAA PAPER 88-0686] p 8 A88-22512
Tether satellite potential for rarefied gas aerodynamic research
[AIAA PAPER 88-0687] p 114 A88-22513
Downward-deployed tethered platforms for high enthalpy aerothermodynamic research
[AIAA PAPER 88-0688] p 114 A88-22514
Applications of tethered satellites to some problems of terrestrial physics
[AIAA PAPER 88-0689] p 114 A88-22515
The tethered satellite electrodynamics experiment project
[AIAA PAPER 88-0690] p 114 A88-22516
The structure of ULF waves produced by a tethered satellite system p 114 A88-23924
The incredibly versatile space tether
p 114 A88-24454
Alfven waves from an electrodynamic tethered satellite system p 115 A88-25890
Construction of a full solution for an integrable case of the problem of the motion of two coupled bodies
p 115 A88-26687
Construction of a full solution to the problem of the relative motion of a system of two bodies
p 115 A88-26688
Geostationary tether satellite system and its application to communications systems p 115 A88-28974
Research on Electrodynamic Tether Effects (RETE) experiment Electrical Ground Support Equipment (EGSE) — tethered satellite
[IFSI-87-2] p 100 N88-13378
RETE experiment Assembly, Integration, and Verification (AIV) activities
[IFSI-87-6] p 117 N88-13380
Tethers in space handbook
[NASA-CR-181371] p 118 N88-14123
Laboratory simulation of the electrodynamic interactions of a tethered satellite with an ionospheric plasma
[IFSI-88-3] p 119 N88-15822
Tethers: An outline of a new concept for Earth observation p 120 N88-16781
Kinetic isolation tether experiment
[NASA-CR-182458] p 120 N88-16810

TETHERING
Coaxial tube array space transmission line characterization p 75 A88-11865
Plasma contactors for use with electrodynamic tethers for power generation
[IAF PAPER 87-251] p 69 A88-15870
Tethers in space - A broad perspective
[AIAA PAPER 88-0530] p 113 A88-22396
Comments on the 'early experimental validation' session of the Second International Conference on Tethers in Space
[AIAA PAPER 88-0535] p 113 A88-22400
Phase 3 study of selected tether applications in space. Volume 2: Study results
[NASA-CR-179186] p 116 N88-10829
Electrodynamic tether system study
[NASA-CR-172024] p 117 N88-11737
Analytical investigation of the dynamics of tethered constellations in Earth orbit (phase 2)
[NASA-CR-179218] p 117 N88-12533
Tethers in space handbook
[NASA-CR-181371] p 118 N88-14123
Tether Elevator Crawler Systems (TECS)
p 119 N88-15631
Plasma contactors for use with electrodynamic tethers for power generation
[NASA-CR-182424] p 73 N88-16547
Kinetic isolation tether experiment
[NASA-CR-182458] p 120 N88-16810

TETHERLINES
Tether technology - Conference summary
[AIAA PAPER 88-0533] p 113 A88-22398
The incredibly versatile space tether
p 114 A88-24454
Absorptive tethers - A first test in space
p 115 A88-27781
Study of Plasma Motor Generator (PMG) tether system for orbit reboost
[NASA-CR-172016] p 117 N88-12501
Tethers in space handbook
[NASA-CR-181371] p 118 N88-14123
Power and charge dissipation from an electrodynamic tether p 73 N88-14869

THERMAL ANALYSIS
Thermal design of the equipment platforms
[IAF PAPER 87-06] p 34 A88-15806
Space station systems: A bibliography with indexes
[NASA-SP-7056(05)] p 5 N88-13382
Development of an emulation-simulation thermal control model for space station application
[NASA-CR-182409] p 37 N88-15823
Analytical interactive approach for phenomena involving structures, thermal and control aspects. Volume 1: Theory — spacecraft structures
[ESA-CR(P)-2503-VOL-1] p 60 N88-16803
Analytical interactive approach for phenomena involving structures, thermal, and control aspects. Volume 2: Toward the solution — spacecraft structures
[ESA-CR(P)-2503-VOL-2] p 60 N88-16804
Analytical interactive approach for phenomena involving structures, thermal, and control aspects. Volume 3: Executive summary — spacecraft structures
[ESA-CR(P)-2503-VOL-3] p 60 N88-16805

THERMAL CONDUCTIVITY
Thermal contact conductance in the presence of thin metal foils
[AIAA PAPER 88-0466] p 35 A88-22342
Thermal contact conductance of pressurized surfaces
[AIAA PAPER 88-0467] p 36 A88-22343

THERMAL CONDUCTORS
Pumped two-phase ammonia thermal bus test bed
[SAE PAPER 871442] p 34 A88-21104

THERMAL CONTROL COATINGS
Development of a thermal control coating for space suits
[SAE PAPER 871474] p 34 A88-21129
Preliminary design of the Space Station internal thermal control system
[SAE PAPER 871505] p 35 A88-21151
Discharge prevention of geosynchronous orbit conductive thermal control materials and grounding systems p 76 N88-11732
Low Earth orbit environmental effects on the space station photovoltaic power generation systems
[NASA-TM-100230] p 73 N88-12429
Space environmental considerations for a long-term cryogenic storage vessel p 80 N88-15933

THERMAL ENERGY
Selection of high temperature thermal energy storage materials for advanced solar dynamic space power systems p 64 A88-11801

THERMAL ENVIRONMENTS
Fourteenth Space Simulation Conference: Testing for a Permanent Presence in Space
[NASA-CP-2446] p 5 N88-10829
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems
[NASA-TM-89705] p 88 N88-15497

THERMAL INSULATION
Thermal response of integral multicomponent composites to a high-energy aerothermodynamic heating environment with surface temperature to 1800 K
p 10 A88-12581
Space environmental considerations for a long-term cryogenic storage vessel p 80 N88-15933

THERMAL PROTECTION
Space suit extravehicular hazards protection development
[NASA-TM-100458] p 157 N88-12927

220

National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 2
[NASA-CR-172009-VOL-2] p 166 N88-14874
Raman spectra of adsorbed layers on space shuttle and AOTV thermal protection system surface
p 132 N88-14890

THERMAL RADIATION
Development of a thermal control coating for space suits
[SAE PAPER 871474] p 34 A88-21129

THERMAL RESISTANCE
High temperature resistant compliant modified epoxies
p 95 A88-29585

THERMAL STABILITY
High temperature resistant compliant modified epoxies
p 95 A88-29585

THERMAL STRESSES
High temperature resistant compliant modified epoxies
p 95 A88-29585
Oxidation and protection of fiberglass-epoxy composite masts for photovoltaic arrays in the low Earth orbital environment
[NASA-TM-100639] p 97 N88-18734

THERMAL VACUUM TESTS
Thermal contact conductance of pressured surfaces
[AIAA PAPER 88-0467] p 36 A88-22343
Thermal environment simulator for vacuum testing of large spacecraft p 36 A88-25979

THERMODYNAMIC PROPERTIES
Solar dynamic heat receiver thermal characteristics in low earth orbit
[AIAA PAPER 88-0472] p 71 A88-22348

THERMOELASTICITY
Finite-element model for the thermoelastic analysis of large composite space structures p 14 A88-19632

THERMOELECTRICITY
Thermoelectric integrated membrane evaporation subsystem testing
[SAE PAPER 871446] p 40 A88-21106

THERMONUCLEAR POWER GENERATION
Study of Plasma Motor Generator (PMG) tether system for orbit reboost
[NASA-CR-172016] p 117 N88-12501

THERMOPHORESIS
Atmospheric science p 5 N88-15357

THERMOPHYSICAL PROPERTIES
Development of a thermal control coating for space suits
[SAE PAPER 871474] p 34 A88-21129
Thermophysical Properties Measurement Facility (TPMF) — Columbus space station
[ESA-CR(P)-2417] p 6 N88-10981

THERMOSETTING RESINS
Advanced materials technology '87; Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr. 6-9, 1987
p 1 A88-13126

THERMOSPHERE
Outer atmospheric research
[AIAA PAPER 88-0686] p 8 A88-22512

THREAT EVALUATION
Space Station Program threat and vulnerability analysis
[AIAA PAPER 87-3082] p 104 A88-26210

THRUST MEASUREMENT
Space station propulsion technology
[NASA-CR-179260] p 80 N88-15835

TIME LAG
A model-free method for mass spectrometer response correction — for oxygen consumption and cardiac output calculation p 111 A88-19883
Teleoperation and control study — orbital servicing
[BAE-TP-8268] p 87 N88-10489

TIME OPTIMAL CONTROL
Optimal time free nodal transfers between elliptical orbits
[IAF PAPER 87-325] p 78 A88-16021
Feedback control design for smooth, near minimum time rotational maneuvers of flexible spacecraft
[AIAA PAPER 88-0671] p 51 A88-22501
Minimum time attitude slewing maneuvers of a rigid spacecraft
[AIAA PAPER 88-0675] p 52 A88-22505

TOLERANCES (MECHANICS)
Pinhole occulter experiment
[NASA-CR-179206] p 116 N88-11481

TOLUENE
Toluene stability Space Station Rankine power system
p 63 A88-11794
Binary mercury/organic Rankine cycle power systems
p 63 A88-11795

TOPOGRAPHY
Observations of ocean and sea bottom relief from space p 143 A88-26099

TORQUE
Predictive momentum management for a space station measurement and computation requirements
[NASA-CR-172026] p 58 N88-10866

TORQUE MOTORS
Application of magnetic bearings to high-torque, satellite attitude control wheels p 47 A88-11908

TOUGHNESS
Carbon fiber reinforced glass matrix composites for space based applications
[AD-A184355] p 96 N88-12548

TOXIC HAZARDS
Space station internal environmental and safety concerns p 156 N88-12527
Monitoring of space station life support systems with miniature mass spectrometry and artificial intelligence
p 45 N88-16376

TOXICITY
Rapid toxicity detection in water quality control utilizing automated multispecies biomonitoring for permanent space stations p 44 N88-10848

TOXICOLOGY
Toxicological aspects of water recycle and disinfection
[SAE PAPER 871491] p 42 A88-21145

TRACKING RADAR
Laser Docking System Radar flight experiment
p 47 A88-12914

TRADEOFFS
Electrical power system for low earth orbit spacecraft applications p 65 A88-11817

TRAINING SIMULATORS
Onboard training for the Space Station
[AIAA PAPER 88-0445] p 154 A88-22331

TRAJECTORIES
Cartesian path control of a two-degree-of-freedom robot manipulator
[NASA-CR-182331] p 88 N88-13908

TRAJECTORY ANALYSIS
Effect of rotating earth for analysis of aeroassisted orbital transfer vehicles p 3 A88-26257
Aeroassisted orbit transfer vehicle trajectory analysis
[NASA-TM-89138] p 62 N88-19575

TRAJECTORY CONTROL
Automatic control in space 1985 p 50 A88-16276
Cartesian path control of a two-degree-of-freedom robot manipulator
[NASA-CR-182331] p 88 N88-13908

TRAJECTORY OPTIMIZATION
Optimal trajectories for aeroassisted, noncoplanar orbital transfer. II - LEO-to-LEO transfer
[IAF PAPER 87-329] p 49 A88-16024
Safe rendezvous approach to a space station by impulsive transfers and continuous thrust arcs
p 151 N88-19486
Safe and fuel minimum reference trajectories for closed loop controlled approaches — space stations
p 61 N88-19488

TRANSFER OF TRAINING
National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 1
[NASA-CR-172009-VOL-1] p 166 N88-14855

TRANSFER ORBITS
Capture-ejector satellites p 108 A88-11726
Orbit design for a space ambulance vehicle
p 149 A88-15313
Challenge '95 - The Ariane 5 Development Programme
[IAF PAPER 87-185] p 137 A88-15826
The space based OTV and the establishment of the next launch site
[IAF PAPER 87-196] p 149 A88-15833
Optimal trajectories for aeroassisted, noncoplanar orbital transfer. II - LEO-to-LEO transfer
[IAF PAPER 87-329] p 49 A88-16024
High-energy orbit refueling for orbital transfer vehicles
p 150 A88-27887
Safe rendezvous approach to a space station by impulsive transfers and continuous thrust arcs
p 151 N88-19486
Cost-effective orbit transfer modes for satellite retrieval and servicing — Space Station p 61 N88-19489

TRANSIENT LOADS
Dynamic characterization of structures by pulse probing and deconvolution
[AIAA PAPER 88-2230] p 21 A88-32193

TRANSIENT RESPONSE
Transient response of joint dominated space structures - A new linearization technique
[AIAA PAPER 88-2393] p 24 A88-32325

TRANSMISSION LINES
Coaxial tube array space transmission line characterization p 75 A88-11865

TRANSMISSION LOSS
Comparative study of cable construction for 20 kHz power distribution p 66 A88-11831

TRANSPORT AIRCRAFT
Aerothermodynamics - A key to new aerospace transport systems
[DGLR PAPER 87-077] p 4 A88-32477

TRANSPORTATION
A lunar transportation system
[NASA-CR-182561] p 107 N88-19379

TRAVELING WAVES
Modeling and control of large flexible vehicles in the atmosphere and space
[AD-A185368] p 27 N88-13377

TRENDS
Communication satellite technology trends
p 76 N88-10088

TRUSSES
Self-shadowing effects on the thermal-structural response of orbiting trusses p 32 A88-11734
Fabrication and assembly of an advanced composite Space Station tetrahedral cell p 11 A88-13189
Protective coatings for composite tubes in space applications p 94 A88-13239
A general truss system for very large space base foundations, with application to the solar power satellite
[IAF PAPER 87-249] p 11 A88-15967
Research and development of the tension truss antenna
[IAF PAPER 87-317] p 12 A88-16015
Two-dimensionally deployable 'SHOF' truss
[IAF PAPER 87-319] p 12 A88-16017
Structures and materials technology for Space Station
[AIAA PAPER 88-2446] p 17 A88-31377
Design and development of the truss assembly fixture for Space Station assembly operations
[AIAA PAPER 88-2455] p 18 A88-31380
Damage detection and location in large space trusses
[AIAA PAPER 88-2461] p 18 A88-31384
Dynamics and control of a planar truss actuator
p 55 A88-31564
Modal coupling of structures with complex storage moduli p 20 A88-31580
Experimental study of damping of graphite epoxy composite material of the Space Telescope truss system
p 56 A88-31605
Vibration control of truss beam structures using axial force actuators
[AIAA PAPER 88-2273] p 22 A88-32229
The component-mode method in a parallel computer environment
[AIAA PAPER 88-2438] p 9 A88-32355
Passive damping for space truss structures
[AIAA PAPER 88-2469] p 24 A88-32360
Effect of joint damping and joint nonlinearity on the dynamics of space structures
[AIAA PAPER 88-2480] p 57 A88-32362
Enhancement of frequency and damping in large space structures with extendable members
[AIAA PAPER 88-2482] p 57 A88-32363
Simultaneous structural and control optimization via linear quadratic regulator eigenstructure assignment
p 28 N88-13622
Continuum modeling of large lattice structures: Status and projections
[NASA-TP-2767] p 26 N88-14115
Chromic acid anodizing of aluminum foil
[NASA-CR-178417] p 97 N88-15077
Space station structures development
[NASA-CR-179261] p 30 N88-16792
Solar concentrator advanced development program, task 1
[NASA-CR-179469] p 74 N88-18068
The integration of a mesh reflector to a 15-foot box truss structure. Task 3: Box truss analysis and technology development
[NASA-CR-178229] p 31 N88-18941

TWO BODY PROBLEM
Construction of a full solution to the problem of the relative motion of a system of two bodies
p 115 A88-26088

TWO PHASE FLOW
Pumped two-phase ammonia thermal bus test bed
[SAE PAPER 871442] p 34 A88-21104
Thermal Control Working Group report
p 36 N88-10094

U

U.S.S.R.
USSR report: Space
[JPRS-USP-87-003] p 144 N88-10050

U.S.S.R. SPACE PROGRAM
USSR export possibilities in the field of space hardware
[SAE PAPER 871342] p 133 A88-14368
Development experience of the attitude control system using single-axis control moment gyros for long-term orbiting space stations
[IAF PAPER 87-04] p 48 A88-15804
The passive attitude motion of the orbital stations Salyut-6 and Salyut-7
[IAF PAPER 87-355] p 49 A88-16045
Thirty years of the space age p 152 A88-16074
Biomedical payload of the French-Soviet long duration flight
[IAF PAPER 87-041] p 152 A88-16159
1986 - Very good year for Soviets
p 136 A88-16379
Soyuz enters third decade p 136 A88-16700
Endurance record broken p 136 A88-16699
Soviet shuttle for Space Station role
p 136 A88-16700
Solar power satellites - Still in the dark
p 70 A88-19002
New space priorities in the USSR p 139 A88-19626
The Soviet space flight project MIR
p 139 A88-20054
Spaceward ho -- U.S. and Soviet space programs
[AIAA PAPER 88-0750] p 160 A88-22547
Space near and far -- Russian book
p 143 A88-27734
Cosmonauts observe supernova p 144 A88-30169
The Soviet cosmonaut team, 1978-1987
p 144 A88-30185
Blagov commentary on Mir station, first manning
p 144 N88-19051
JPRS report: Science and technology: USSR: Space
[JPRS-USP-87-006] p 146 N88-16063
Basic results of medical studies during prolonged manned flights on board the Salyut-7/Soyuz-T orbital complex
[NASA-TT-20217] p 147 N88-18182
Medlab: A project of a medical laboratory in space
p 153 N88-19946

UK SPACE PROGRAM
Past, present and future activities in space power technology in the UK
[IAF PAPER 87-240] p 69 A88-15964

ULTRASONICS
Wave propagation experiments on 22-bay lattice
[AD-A186140] p 29 N88-15002

UNITED STATES
National jurisdiction on the Space Station
p 160 A88-13450
Principles of operations cooperation between the United States and Europe p 141 A88-21564
The civil space program: An investment in America - Report of an AIAA Workshop p 164 A88-23925
Advancing automation and robotics technology for the space station and for the US economy: Submitted to the United States Congress October 1, 1987
[NASA-TM-100777] p 88 N88-15818
Advancing automation and robotics technology for the space station and for the US economy: Submitted to the United States Congress October 1, 1986
[NASA-TM-89190] p 89 N88-15819
America plans for space
[AD-A187465] p 167 N88-17713

UNMANNED SPACECRAFT
Simulation tools for the development of an autonomous rendezvous and docking system p 47 A88-13572

UPPER ATMOSPHERE
SAFIRE - A novel high resolution cooled spectrometer for atmospheric research
[IAF PAPER 87-137] p 109 A88-15894
Outer atmospheric research
[AIAA PAPER 88-0686] p 8 A88-22512

USER MANUALS (COMPUTER PROGRAMS)
Space station integrated wall design and penetration damage control
[NASA-CR-179169] p 25 N88-10070

USER REQUIREMENTS
A model for enveloping Space Station logistics requirements p 102 A88-15286
Science plans and requirements for the U.S./International Space Station
[IAF PAPER 87-93] p 103 A88-15864
The potential of Columbus element utilisation
[IAF PAPER 87-94] p 137 A88-15865
Space Station services and design features for users
[IAF PAPER 87-98] p 103 A88-15870
Microgravity research and user support in the Space Station era - The Microgravity User Support Center
[IAF PAPER 87-390] p 110 A88-16061
FACILE - A computer program for Space Station facilities layout and activity simulation
[SAE PAPER 871415] p 7 A88-21079
Development of an automated checkout, service, and maintenance system for an EVAS Space Station
[SAE PAPER 871497] p 124 A88-21149
Eureca - European user-friendly retrievable carrier
p 139 A88-21251
A data base approach towards Columbus payload accommodation p 99 A88-21257
From Space Shuttle to Space Station - Graduating from paper to electronic media
[AIAA PAPER 88-0442] p 163 A88-22329
Telescience testbedding for life science missions on the Space Station
[AIAA PAPER 88-0446] p 86 A88-22332
Space station platforms p 116 N88-10086
Spacecraft Systems Working Group report
p 165 N88-10091
Orbital Spacecraft Consumables Resupply System (OSCRS). Volume 4: Extended study results
[NASA-CR-172012] p 126 N88-11686
Orbital Spacecraft Consumables Resupply System (OSCRS). Volume 1: Executive summary
[NASA-CR-172010] p 126 N88-13367
Customer concerns regarding satellite servicing
p 129 N88-19503
Conceptual design and programmatics studies of space station accommodations for Life Sciences Research Facilities (LSRF)
[NASA-CR-179270] p 46 N88-19567

UTILIZATION
Carbofiex - A new general purpose pitch-based carbon fiber p 94 A88-13902

V

VACUUM TESTS
Outgassing data for selecting spacecraft materials
[NASA-RP-1124] p 95 N88-10117

VAPOR PRESSURE
Vapor compression distiller and membrane technology for water revitalization p 39 A88-17072

VARIABLE GEOMETRY STRUCTURES
A finite element method for time varying geometry in multibody structures
[AIAA PAPER 88-2234] p 21 A88-32197

VECTOR ANALYSIS
Computational methods for problems in aerodynamics and large space structure using parallel and vector architectures
[AD-A185401] p 27 N88-13294

VEGETATION GROWTH
Solar plant growth facility (SPGF) - An approach toward future biological life support systems
p 155 A88-29141
Progress in European CELSS activities
p 44 N88-12252

VENTILATION
Intermodule ventilation studies for the Space Station
[SAE PAPER 871428] p 130 A88-21091

VERTICAL DISTRIBUTION
Reconstruction of the vertical atmospheric temperature profile on the basis of refraction measurements from the Salyut-7 orbital station p 131 A88-23930

VIBRATION DAMPING
Robustness of active modal damping of large flexible structures p 11 A88-13929
Modal damping measurement of MOS-1 Solar Array Paddle p 13 A88-16292
Maneuvering and vibration control of flexible spacecraft p 52 A88-22932
Decentralized/hierarchical control for large flexible spacecraft
[M88-UR-967-87] p 52 A88-23962
Optimization of actively controlled structures using goal programming techniques p 53 A88-25797
An experimental study on flexible spacecraft three-axis attitude control p 53 A88-26356
Active vibration control on the OSU flexible beam
p 15 A88-27357
A survey of decentralized control techniques for large space structures p 16 A88-27359
Three-axis rotational maneuver and vibration stabilization of elastic spacecraft p 54 A88-27364
Control of distributed parameter systems with spillover using an augmented observer p 16 A88-27377
Active modification of wave reflection and transmission in flexible structures p 16 A88-27395
A homotopy algorithm for solving the optimal projection equations for fixed-order dynamic compensation - Existence, convergence and global optimality
p 16 A88-27401
Measurement and modeling of joint damping in space structures
[AIAA PAPER 88-2449] p 17 A88-31378
Spillover stabilization of large space structures
[AIAA PAPER 88-2484] p 55 A88-31393
The role of damping in vibration and noise control; Proceedings of the Eleventh Biennial Conference on Mechanical Vibration and Noise, Boston, MA, Sept. 27-30, 1987 p 20 A88-31573
Design and analysis of passively damped large space structures p 56 A88-31574
Large space structure damping treatment performance - Analytic and test results p 20 A88-31586
Comparison of experimental techniques in the measurement of damping capacity of metal-matrix composites p 56 A88-31600
Experimental study of damping of graphite epoxy composite material of the Space Telescope truss system
p 56 A88-31605
Control for energy dissipation in structures
[AIAA PAPER 88-2272] p 22 A88-32229
Vibration control of truss beam structures using axial force actuators
[AIAA PAPER 88-2273] p 22 A88-32229
System identification of flexible structures
[AIAA PAPER 88-2361] p 23 A88-32301
Effect of joint damping and joint nonlinearity on the dynamics of space structures
[AIAA PAPER 88-2480] p 57 A88-32362
Enhancement of frequency and damping in large space structures with extendable members
[AIAA PAPER 88-2482] p 57 A88-32363
Combined problem of slew maneuver control and vibration suppression
[NASA-CR-181537] p 59 N88-12817
Viscous damped space structure for reduced jitter
p 28 N88-13623
Active control of flexural vibrations in beams
p 59 N88-14888
Kinetic isolation tether experiment
[NASA-CR-182458] p 120 N88-16810
Sensitivity of active vibration control to structural changes and model reduction p 30 N88-17683

VIBRATION EFFECTS
Materials processing twin experiment
[AIAA PAPER 88-0348] p 163 A88-22255

VIBRATION ISOLATORS
Disturbance and vibration isolation in space stations by means of mechanical decoupling p 11 A88-13932
Pointing mount with active vibration isolation for large payloads
[AAS PAPER 87-033] p 103 A88-16990
Large space structure damping treatment performance - Analytic and test results p 20 A88-31586
Fractional derivatives in the description of damping materials and phenomena p 20 A88-31589
An investigation of the damping phenomena in wire rope isolators p 21 A88-31597
Modeling and control of large flexible vehicles in the atmosphere and space
[AD-A185368] p 27 N88-13377

VIBRATION MEASUREMENT
Root locus method for active control of flexible systems p 53 A88-24506

VIBRATION MODE
On control of tethered satellite systems
p 110 A88-16294
Modal coupling of structures with complex storage moduli p 20 A88-31580
Survey of parameter estimation methods in experimental modal analysis p 24 A88-32718

VIBRATION TESTS
Active vibration control in microgravity environment
p 55 A88-31565
The nonlinear behavior of a passive zero-spring-rate suspension system
[AIAA PAPER 88-2318] p 57 A88-32274
NASDA's new test facilities for satellites and rockets
p 147 N88-18951

VIDEO EQUIPMENT
A packetised remote visual access data system for Space Station interactive payload operations
p 99 A88-21253
Video-based satellite attitude determination
p 51 A88-21657

VIEWING
Space Station viewing requirements
[SAE PAPER 861754] p 1 A88-10155

VISCOELASTIC DAMPING
Large space structure damping treatment performance - Analytic and test results p 20 A88-31586
Fractional derivatives in the description of damping materials and phenomena p 20 A88-31589
Passive damping for space truss structures
[AIAA PAPER 88-2469] p 24 A88-32360

VISCOMETERS
High intensity 5 eV O-atom exposure facility for material degradation studies p 96 N88-10947

VISCOUS DAMPING
Very high damping in large space structures
p 20 A88-31594

Investigation of damping from nonlinear sleeve joints of large space structures p 56 A89-31586
Viscous damped space structure for reduced jitter p 28 N89-13023

VISCOUS FLUIDS
Very high damping in large space structures p 20 A89-31584

VISION
Solid modelling for the manipulative robot arm (power) and adaptive vision control for space station missions p 89 N89-16439

VISUAL OBSERVATION
Observations of ocean and sea bottom relief from space p 143 A89-26099

VISUAL PERCEPTION
Space vehicle approach velocity judgments under simulated visual space conditions [NASA-TM-89437] p 158 N89-19094

W

WALLS
Space station integrated wall design and penetration damage control [NASA-CR-179189] p 21 N89-10070
Space station integrated wall damage and penetration damage control. Task 5: Space debris measurement, mapping and characterization system [NASA-CR-179281] p 30 N89-17688

WARNING SYSTEMS
Techniques for fire detection p 158 N89-12521
EUREX D: An expert system for failure diagnosis and recovery in the TCS of the European retrievable carrier EURECA p 146 N89-16385

WASTE DISPOSAL
An evaluation of heat pipe radiators incorporating pumped liquid return p 33 A89-11810
Space Station supply, product return, and trash disposal [IAF PAPER 87-219] p 123 A89-15949

WASTE HEAT
An evaluation of heat pipe radiators incorporating pumped liquid return p 33 A89-11810
Thermal contact conductance of pressurized surfaces [AIAA PAPER 88-0467] p 36 A89-22343

WASTE TREATMENT
Catalytic processes for space station waste conversion [NASA-CR-177423] p 44 N89-10491
Controlled Ecological Life Support Systems (CELSS) physochemical waste management systems evaluation [NASA-CR-177422] p 45 N89-14626
Electrochemical processing of solid waste [NASA-CR-182413] p 157 N89-15952

WASTE UTILIZATION
Catalytic processes for space station waste conversion [NASA-CR-177423] p 44 N89-10491

WASTE WATER
Thermoelectric integrated membrane evaporation subsystem testing [SAE PAPER 871446] p 40 A89-21106
Recent developments in water quality monitoring for Space Station reclaimed wastewaters [SAE PAPER 871447] p 40 A89-21107
Test results of a shower water recovery system [SAE PAPER 871512] p 42 A89-21158
Development of a non-phase-change waste-water treatment subsystem [SAE PAPER 871514] p 43 A89-21159

WATER
Water-propellant resistojets for man-tended platforms [IAF PAPER 87-259] p 79 A89-15975
High pressure water electrolysis for the Space Station [SAE PAPER 871473] p 41 A89-21128

WATER COLOR
Technical aspects of future ocean colour remote sensing p 119 N89-16298

WATER MANAGEMENT
Water management requirements for animal and plant maintenance on the Space Station [SAE PAPER 871469] p 41 A89-21125
Status of the Space Station water reclamation and management subsystem design concept [SAE PAPER 871510] p 42 A89-21156

WATER QUALITY
Recent developments in water quality monitoring for Space Station reclaimed wastewaters [SAE PAPER 871447] p 40 A89-21107
Review of water disinfection techniques [SAE PAPER 871488] p 42 A89-21142
Consequences of bacterial resistance to disinfection by iodine in potable water [SAE PAPER 871489] p 42 A89-21143
Rapid toxicity detection in water quality control utilizing automated multispecies biomonitoring for permanent space stations p 44 N89-10848

WATER RECLAMATION
Selected advanced technology studies for the U.S. Space Station -- waste water reclamation, module design and fabrication [IAF PAPER 87-79] p 2 A89-15854
Thermoelectric integrated membrane evaporation subsystem testing [SAE PAPER 871446] p 40 A89-21106
Recent developments in water quality monitoring for Space Station reclaimed wastewaters [SAE PAPER 871447] p 40 A89-21107
Toxicological aspects of water recycle and disinfection [SAE PAPER 871491] p 42 A89-21145
Status of the Space Station water reclamation and management subsystem design concept [SAE PAPER 871510] p 42 A89-21156
Test results of a shower water recovery system [SAE PAPER 871512] p 42 A89-21158

WATER RESOURCES
Inflight microbial analysis technology [SAE PAPER 871493] p 42 A89-21147

WATER TREATMENT
Vapor compression distiller and membrane technology for water revitalization p 38 A89-17072
Spacecraft water system disinfection technology - Past, present, and future needs [SAE PAPER 871487] p 41 A89-21141
Review of water disinfection techniques [SAE PAPER 871488] p 42 A89-21142
Medical effects of iodine disinfection products in spacecraft water [SAE PAPER 871490] p 154 A89-21144
Treatment bed microbiological control [SAE PAPER 871492] p 42 A89-21146
Inflight microbial analysis technology [SAE PAPER 871493] p 42 A89-21147
Test results of a shower water recovery system [SAE PAPER 871512] p 42 A89-21158
Development of a non-phase-change waste-water treatment subsystem [SAE PAPER 871514] p 43 A89-21159
An overview of Japanese CELSS research activities p 44 N89-12267

WATER VAPOR
Performance evaluation of SPE electrolyzer for Space Station life support [SAE PAPER 871451] p 40 A89-21111

WAVE FRONT DEFORMATION
Wavefront error sensing [NASA-CR-181504] p 76 N89-12030

WAVE PROPAGATION
Active modification of wave reflection and transmission in flexible structures p 16 A89-27395
Dispersion, damping and confinement of propagating pulses in large space structures [AIAA PAPER 88-2311] p 22 A89-32259
Wave propagation experiments on 22-bay lattice [AD-A186140] p 29 N89-15002

WAVE REFLECTION
Active modification of wave reflection and transmission in flexible structures p 16 A89-27395

WEIGHT REDUCTION
Capabilities and special features concerning structural optimization of spacecraft structure [IAF PAPER 87-320] p 12 A89-16018

WEIGHTLESSNESS
Cosmonaut behaviour in orbital flight situation - Preliminary ethological analysis [IAF PAPER 87-526] p 152 A89-16151
Effect of joint damping and joint nonlinearity on the dynamics of space structures [AIAA PAPER 88-2480] p 57 A89-32362
A theoretical concept for state changes and shape changes in weightlessness p 157 N89-15365
Ballistocardiography in weightlessness research p 46 N89-19080

WEIGHTLESSNESS SIMULATION
Dynamic testing of a docking system -- ground-based simulator p 62 N89-19516

WELDED STRUCTURES
Advanced radiator concepts utilizing honeycomb panel heat pipes [NASA-CR-172017] p 37 N89-12747

WELDING MACHINES
An initial study of remotely manipulated stud welding for space applications p 86 A89-31274

WINGED VEHICLES
Development scenario of H-II Orbiting Plane, HOPE [IAF PAPER 87-210] p 48 A89-15943

WIRE
An investigation of the damping phenomena in wire rope isolators p 21 A89-31587

WOOD
Method of radiographic inspection of wooden members [NASA-CASE-LAR-13724-1] p 149 N89-23983

WORK-REST CYCLE
Implications of shiftwork in space for human physiology experiments p 129 N89-15942

WORKING FLUIDS
Performance characteristics of moving belt radiators -- for spacecraft applications p 33 A89-12006
Pumped two-phase ammonia thermal bus test bed [SAE PAPER 871442] p 34 A89-21104
Design of an ammonia two-phase Prototype Thermal Bus for Space Station [SAE PAPER 871506] p 35 A89-21152

WORKSTATIONS
Foundation: Transforming data bases into knowledge bases p 102 N89-16423

X

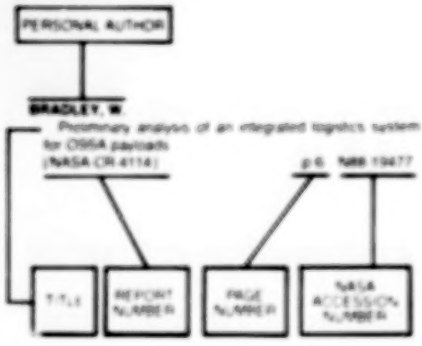
X RAY ASTRONOMY
Minaboona X-ray detector and spacecraft design study p 108 A89-15511
The X-ray large aray. II - Implementation [AIAA PAPER 88-0654] p 14 A89-22486
USSR report: Space [JPRS-USP-87-003] p 144 N89-10050
X-ray astronomy instruments to operate on Mir station p 144 N89-10052

X RAY IMAGERY
AURIC: A proposal for flying auroral imaging observatory on the Polar Platform in the Space Station/Columbus program p 119 N89-16268

X RAY TELESCOPES
Design, analysis, fabrication and test of the LAMAR protoflight mirror assembly -- Large Area Modular Array of Reflectors p 10 A89-12719
The X-ray large aray. II - Implementation [AIAA PAPER 88-0654] p 14 A89-22486
X-ray astronomy instruments to operate on Mir station p 144 N89-10052

223

Typical Personal Author Index Listing



Listings in this index are arranged alphabetically by personal author. The title of the document provides the user with a brief description of the subject matter. The report number helps to indicate the type of document listed (e.g., NASA report, translation, NASA contractor report). The page and accession numbers are located beneath and to the right of the title. Under any one author's name the accession numbers are arranged in sequence with the AIAA accession numbers appearing first.

A

AARSNES, K.
AURIC: A proposal for flying auroral imaging observatory on the Polar Platform in the Space Station/Columbus program p 119 N88-16268

ABDULWAHAB, A.
On a knowledge based assisted system for highly autonomous control of experiment-manipulators in the Man-Tended Free Flyer p 92 N88-19505

ABELES, FRED J.
Development of an automated checkout, service, and maintenance system for an EVAS Space Station (SAE PAPER 871497) p 124 A88-21149

ABRAMOV, I. P.
Crewman rescue equipment in manned space missions - Aspects of application (IAF PAPER 87-578) p 153 A88-16187

ACKERMAN, THOMAS
Atmospheric science p 5 N88-19357

ACOSTA, R. J.
Compensation of reflector antenna surface distortion using an array feed (NASA-TM-100286) p 77 N88-18405

ADAMS, ALAN M.
Technology demonstrator program for Space Station Environmental Control Life Support System (SAE PAPER 871458) p 41 A88-21115

ADAMS, JOHN CARL
Predictive momentum management for a space station measurement and computation requirements (NASA-CR-172026) p 58 N88-10868

ADAMS, RICHARD H.
Remote repair demonstration of Solar Maximum main electronics box p 128 N88-19510

ADLER, DAVID
Photovoltaics for commercial solar power applications; Proceedings of the Meeting, Cambridge, MA, Sept. 18, 19, 1986 (SPIE-706) p 70 A88-21801

AENSHAMSLIN, MARIE-HELENE
Interim Flight Opportunity (IFO) (IAF PAPER 87-579) p 138 A88-16054

AGGSON, THOMAS L.
The effect of photoelectrons on boom satellite potential differences during electron beam ejection (AD-A190390) p 75 A88-20350

AGRAWAL, OM P.
Application of perturbation techniques to flexible multibody system dynamics p 14 A88-20908

AHMED, SELINA
The determination of nutritional requirements for Safe Haven Food Supply System (emergency/survival foods) p 45 N88-14856

AIRAGHI, A.
Fault tolerant onboard implementation of control procedures in tethered satellite p 110 A88-16285

AKIMOTO, T.
Development scenario of H-II Orbiting Plane HOPE (IAF PAPER 87-210) p 48 A88-15943

AKIN, DAVID L.
Structural Assembly Demonstration Experiment (SADE) (NASA-CR-179205) p 26 N88-10868
EASE (Experimental Assembly of Structures in EVA) overview of selected results p 126 N88-10881

AKINFIEV, T. ?
Synthesis of the flexible structures of complex systems p 15 A88-27148

AKISTER, H.
Study of large solar arrays (SOLA) phase 2A (BAE SS/1109) p 74 N88-17106

AKOPOVA, A. B.
Determination of cosmic ray characteristics on Salyut 7 p 131 A88-28349

ALBERT, THOMAS
Space power needs and forecasted technologies for the 1990s and beyond p 71 A88-22877

ALBUS, J. S.
NASA/NBS (National Aeronautics and Space Administration/National Bureau of Standards) standard reference model for Telerobot Control System Architecture (NASREM) (PB88-124773) p 92 N88-17099

ALDAMIZ, A.
Coorbiting Platform Utilization Study (CPLUS): executive summary (SN WP-4000-DOC-8609-95-F) p 120 N88-16799

ALEXANDER, H. L.
Experiments in advanced control concepts for space robotics - An overview of the Stanford Aerospace Robotics Laboratory (AAS PAPER 87-044) p 83 A88-16999

ALEXANDER, J. IWAN D.
Acceleration measurement and management on a space station (IAF PAPER 87-384) p 50 A88-16049
Analysis of low gravity tolerance of model experiments for space station: Preliminary results for directional solidification (NASA-CR-182657) p 10 N88-19648

ALEXANDER, LARRY
Semiautonomous control for satellite servicing (AIAA PAPER 87-2852) p 81 A88-12573

ALEXANDER, R. M.
A general approach to modal analysis for time-varying systems (AIAA PAPER 88-2356) p 23 A88-32296

ALLABANDOLA, LOU
Physics and chemistry p 118 N88-15359

ALLEGRA, ALFIO
Columbus pressurized modules - A challenging opportunity for microgravity research and application (IAF PAPER 87-375) p 137 A88-16050

ALLEN, CHERYL L.
Design and assembly sequence analysis of option 3 for CETF reference space station (NASA-TM-100503) p 126 N88-13369

ALLEN, D. H.
Finite-element model for the thermoelastic analysis of large composite space structures p 14 A88-19632

ALLEN, MARC S.
AUTOPLAN - A PC-based automated mission planning tool p 7 A88-20486

ALLEN, MICHAEL A.
Network management for the Space Station Information System (AIAA PAPER 88-0116) p 99 A88-22082

ALLEN, WILLIAM H.
Application of advanced automation techniques in the Space Station electrical power system p 75 A88-11855

ALLRED, LLOYD
An optically tethered and controlled satellite system (IAF PAPER 87-50) p 109 A88-15835

ALTMANN, G.
Columbus, present programme status (IAF PAPER 87-62) p 135 A88-15841

AMBRUS, JUDITH H.
The impact of launch vehicle constraints on U.S. Space Station design and operations (IAF PAPER 87-72) p 2 A88-15848
Past, present, and future activities in space power technology in the United States of America (IAF PAPER 87-245) p 69 A88-15966

AMIROUCHE, F. M. L.
Dynamics of large constrained flexible structures p 16 A88-29509

ANDARY, JAMES F.
The Flight Telerobotic Servicer (FTS) - A focus for automation and robotics on the Space Station (IAF PAPER 87-25) p 82 A88-15817

ANDERSEN, GREGORY C.
Design and assembly sequence analysis of option 3 for CETF reference space station (NASA-TM-100503) p 126 N88-13369

ANDERSON, C. N.
Laser solar power satellites - A case study in technology forecasting p 68 A88-15492

ANDERSON, JOHN L.
Tether technology - Conference summary (AIAA PAPER 88-0533) p 113 A88-22398
Outer atmospheric research (AIAA PAPER 88-0686) p 8 A88-22512

ANDERSON, RAY H.
EVA construction and repair of tubular systems on Space Station (AIAA PAPER 88-2456) p 125 A88-31381

ANDERSON, ROBERT L.
An overview of space station operations (SAE SP-687) p 122 A88-15575

ANDRESEN, R. D.
The Eureca concept and its importance in preparing the Columbus Programme p 140 A88-21524

ANDRUS, JAMES H.
Pointing mount with active vibration isolation for large payloads (AAS PAPER 87-033) p 103 A88-16995

ANGER, C. D.
AURIC: A proposal for flying auroral imaging observatory on the Polar Platform in the Space Station/Columbus program p 119 N88-16268

ANKENBOELLER, B.
Expert system study for spacecraft management (TL-2699-ISS-1) p 101 N88-15004

ANTSIFEROVA, N. G.
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment p 145 N88-12917

ARBEILLE, PH.
Cardiovascular adaptation to zero-g during a long term flight (237 days) on board the Salyut 7 Soviet space station (1984) p 158 N88-19820
Cardiac and peripheral circulation assessement by ultrasound on 3 astronauts during two 7-day space flights (1982 Salyut-7 - 1985 STS 51G) p 158 N88-19821

ARBOUZ, NASSIM M.
Robust controller design for flexible structures (AD-A197217) p 90 N88-18009

ARCHARD, KAREN R.
Shuttle based assembly of Space Station (AIAA PAPER 88-2452) p 125 A88-31379

ARCHULETA, F. A.
High intensity 5 eV O-atom exposure facility for material degradation studies p 96 N88-10847

224

ARDUINI, C.
Analytical interactive approach for phenomena involving structures, thermal and control aspects. Volume 1: Theory
[ESA-CR(P)-2503-VOL-1] p 60 N86-15803
Analytical interactive approach for phenomena involving structures, thermal, and control aspects. Volume 2: Toward the solution
[ESA-CR(P)-2503-VOL-2] p 60 N86-15804
Analytical interactive approach for phenomena involving structures, thermal, and control aspects. Volume 3: Executive summary
[ESA-CR(P)-2503-VOL-3] p 60 N86-15805
ARDUINI, CARLO
Numerical and numerical-analytical interfaces in structural thermal-dynamic interactive problems
[IAF PAPER 87-322] p 49 A88-16020
ARENO, H.
Costs and benefits of future heavy Space Freighters
[IAF PAPER 87-617] p 162 A88-16211
ARENDS, H.
Laboratory simulation of the electrodynamic interactions of a tethered satellite with an ionospheric plasma
[FSI-86-3] p 119 N86-15622
ARKING, A.
Remote sensing: Earth's surface and atmosphere. Proceedings of Workshop X and the Topical Meeting of the 26th COSPAR Plenary Meeting, Toulouse, France, June 30-July 11, 1986 p 111 A88-17026
ARMSTRONG, E. S.
Design of robust line-of-sight pointing control system for the SCOLE configuration p 54 A88-27367
ARNO, R. D.
Animal research on the Space Station
p 159 N86-19964
ARNO, ROGER D.
Accommodating life sciences on the Space Station
[SAE PAPER 871412] p 36 A88-21077
ARRISON, ANNE
A novel photovoltaic power system which uses a large area concentrator mirror p 65 A88-11611
ASHIDA, A.
Vapor compression distiller and membrane technology for water revitalization p 38 A88-17072
ASHLEY, HOLT
Modeling and control of large flexible vehicles in the atmosphere and space
[AD-A165368] p 27 N86-13377
ASKINS, BARBARA S.
Evolutionary Space Station infrastructure
[IAF PAPER 87-103] p 105 A88-15872
ATKOV, O.
Cardiovascular adaptation to zero-g during a long term flight (237 days) on board the Salyut 7 Soviet space station (1984) p 158 N86-19920
AUFFRAY, P.
The high performance solar array GSR3
[SNIAS-872-422-108] p 73 N86-13814
AURIEMMA, G.
Astromag: A particle spectrometer for the Space Station
[PREPRINT-557] p 118 N86-14336
AYDELOTT, JOHN C.
Cryogenic Fluid Management Technology Workshop. Volume 1: Presentation material and discussion
[NASA-CP-10001] p 80 N86-15924
AYERS, SCHUYLER R.
Development of composite facets for the surface of a space-based solar dynamic concentrator
p 70 A88-18230

B

BABEL, HANK
Stress rupture behavior of carbon-fiber metal-lined pressure vessels for 30-year operation in space
[AIAA PAPER 88-2479] p 19 A88-31391
BABRAUSKAS, VYTENIS
Fire-related standards and testing
p 156 N86-12522
BACHTELL, E. E.
The integration of a mesh reflector to a 15-foot box truss structure. Task 3: Box truss analysis and technology development
[NASA-CR-178228] p 31 N86-18941
BADER, CLAYTON H.
Component data base for space station resistojet auxiliary propulsion
[NASA-CR-180034] p 81 N86-17731
BAGDIGIAN, R. M.
Status of the Space Station water reclamation and management subsystem design concept
[SAE PAPER 871510] p 42 A88-21156
BAGLEY, D. L.
Fractional derivatives in the description of damping materials and phenomena p 20 A88-31589
BAILEY, ELLEN A.
Power and resource management scheduling for scientific space platform applications
p 106 A88-11880
BAINUM, PETER M.
The dynamics and control of large space structures after the onset of thermal shock
[IAF PAPER 87-351] p 49 A88-16041
Minimum time attitude slewing maneuvers of a rigid spacecraft
[AIAA PAPER 88-0675] p 52 A88-22505
The dynamics and control of large flexible space structures, part 10
[NASA-CR-182426] p 29 N88-15830
BAKER, STEPHEN D.
Some considerations on measuring the Newtonian gravitational constant G in an orbiting laboratory
p 119 N88-15603
BALDETTI, P.
Mechanical design of the ac bracket package for the RETE experiment
[FSI-87-4] p 145 N88-13379
BALLARD, RODNEY W.
The opportunities for space biology research on the Space Station p 153 A88-20282
The opportunities for space biology research on the Space Station p 155 A88-29134
BANDA, S. S.
(M,N)-approximation - A system simplification method
p 54 A88-27402
BANGHAM, MICHAL E.
A computer aided engineering tool for ECLS systems
[SAE PAPER 871423] p 98 A88-21087
BANHOLZER, WILLIAM F.
Oxidation-resistant reflective surfaces for solar dynamic power generation in near earth orbit p 70 A88-19523
BANICHUK, N. V.
Sensitivity analysis and optimal design for large unrestrained structures
[IAF PAPER 87-321] p 12 A88-16019
BANKS, PETER M.
Science plans and requirements for the U.S./International Space Station
[IAF PAPER 87-93] p 103 A88-15864
BARACAT, W. A.
Tethers in space handbook
[NASA-CR-181371] p 118 N88-14123
BARBERA, ROMANO
The Columbus Attached Pressurized Module - System and management aspects of international cooperation
p 139 A88-21252
BARBERIS, NEIL
Geostationary earth observations - Platform operations from the Space Station
[IAF PAPER 87-19] p 108 A88-15814
BARKER, ROBERT S.
G189 computer program modeling of environmental control and life support systems for the Space Station
[SAE PAPER 871427] p 39 A88-21090
BARRETTA, G.
Interoperability and integration of data relay satellite systems p 76 N88-12134
BARTEVIAN, J.
The high performance solar array GSR3
[SNIAS-872-422-108] p 73 N86-13814
BARTHELME, NEAL
The 1987 Get Away Special Experimenter's Symposium
[NASA-CP-2500] p 121 N88-17691
BARUCH, MENAHEM
A criterion for shape control robustness of space structures p 16 A88-29720
BARUH, H.
A recursive pole placement method for large flexible structures p 19 A88-31567
BASILE, L.
A new Italian proposal for a Space Station Assembly and Servicing Vehicle (ASMV)
[IAF PAPER 87-57] p 135 A88-15827
BASS, J. N.
Analysis of geophysical data bases and models for spacecraft interactions
[AD-A184809] p 100 N86-13375
BASSNER, H.
Solar- and nuclear electric propulsion for high energy orbits
[IAF PAPER 87-198] p 77 A88-15935
BASTARD, J. L.
The high performance solar array GSR3
[SNIAS-872-422-108] p 73 N86-13814
BATE, R.
Columbus pressurized module utilization study, executive summary
[CS-RP-AI-027] p 146 N88-15005
BATE, RAYMOND
Trends to reduce development and operation costs for experiments of the future space laboratory
[IAF PAPER 87-100] p 105 A88-15871
BATTRICK, BRUCE
ESA Bulletin No. 25
[ISSN-0376-4265] p 146 N88-16767
BAY, P. M.
Technology advancements for servicing of future spacecraft systems
[IAF PAPER 87-36] p 122 A88-15826
BAYEVSKIY, R. M.
Ballistocardiography in weightlessness research
p 46 N88-19080
BEALE, G.
Development of a coupled expert system for the spacecraft attitude control problem p 61 N88-17223
BEAM, J. E.
Roll-out-fin expandable space radiator concept
p 36 A88-30320
BEARD, B.
Design concepts for bioreactors in space
p 45 N88-17179
BEARDSLEY, ANTHONY C.
Development of an automated checkout, service, and maintenance system for an EVAS Space Station
[SAE PAPER 871497] p 124 A88-21149
BEATTY, J. KELLY
The high-flying Kvant module p 139 A88-20457
BEBERMEIER, H.
Study of large solar arrays (SOLA), phase 2A
[BAE-SS/1109] p 74 N88-17106
BECKER, CHRISTOPHER
Physics and chemistry p 118 N88-15359
BECUS, G. A.
Simultaneous structural and control optimization via linear quadratic regulator eigenstructure assignment
p 28 N88-13622
BEEKMAN, D. H.
Space station onboard propulsion system: Technology study
[NASA-CR-179233] p 80 N88-15006
BEER, C. M.
Space station onboard propulsion system: Technology study
[NASA-CR-179233] p 80 N88-15006
BEGG, LESTER L.
Comparison of high temperature heat reaction concepts to system-related requirements p 33 A88-11809
BEHRENS, G.
Study of large solar arrays (SOLA), phase 2A
[BAE-SS/1109] p 74 N88-17106
BEHRLE, R.
Preliminary study of a containerless processing facility for Columbus, executive summary
[ESA-ITT-AO/1-1,834/85F] p 96 N88-10203
Prephase A study of a crystallization laboratory for Columbus, executive summary
[ESA-ITT/AO/1-1868/85F] p 96 N88-10206
BEJCZY, A. K.
Computing architecture for telerobots in earth orbit
p 99 A88-21650
BEKEY, G. A.
On the modelling and control of a flexible manipulator arm by point actuators p 92 A88-14996
BEKEY, IVAN
Long range planning at NASA
[IAF PAPER 87-670] p 163 A88-16243
BEL'MADI, M.
Stratospheric luminescence observed from the Salyut-7 station p 144 A88-30076
BELAU, W.
EUREX D: An expert system for failure diagnosis and recovery in the TCS of the European retrievable carrier EURECA p 148 N88-16385
BELIAEV, M. IU.
Problem of control arisen during the implementation of scientific research program onboard the multipurpose orbital stations
[IAF PAPER 87-106] p 49 A88-15874
The passive attitude motion of the orbital stations Salyut-6 and Salyut-7
[IAF PAPER 87-355] p 49 A88-16045
BELVIN, W. KEITH
Structural tailoring and feedback control synthesis - An interdisciplinary approach
[AIAA PAPER 88-2306] p 21 A88-32177
BENTALL, R. H.
The ESA/Fokker service end-effector subsystem. A robotic/man-compatible servicing approach
p 92 N88-19502

225

Motion simulation for in-orbit operations
p 62 N88-10514
Man-tended options for European space robotics
p 94 N88-19538

BENTS, DAVID J.
Coaxial tube array space transmission line characterization
p 75 A88-11865

BENZ, FRANK J.
Ignition and combustion of metals in oxygen
p 79 N88-12530

BERCAW, ROBERT R.
LERC power system autonomy program 1990 demonstration
p 67 A88-11861

BERCAW, ROBERT W.
Spacecraft 2000 program overview
p 165 N88-10085

BERGER, G.
Robotic sensors and actuators for a service manipulator system. Volume 1: Executive summary
[MATRA-EPT/DT/VT187/120]
p 87 N88-10341
Robotic sensors and actuators for a service manipulator system. Volume 2: Service Manipulator System (SMS) handbook
[MATRA-EPT/DT/VT187/227]
p 87 N88-10342
Robotic sensors and actuators for a service manipulator system. Volume 3, phase A report and program plan
[MATRA-EPT/DT/VT187/229]
p 87 N88-10343

BERGMAN, D.
Space station integrated propulsion and fluid system study. Fluid systems configuration databook
[NASA-CR-179215]
p 79 N88-11753

BERMAN, DOUGLAS
Autonomous management of the Space Station electric energy system
p 71 A88-21641

BERNASCONI, M. C.
Large inflatable, space-rigidized antenna reflectors - Land mobile services development
[IAF PAPER 87-315]
p 12 A88-16013

BERNSTEIN, DENNIS S.
Maximum entropy/optimal projection design synthesis for decentralized control of large space structures
[AD-A186359]
p 29 N88-15003

BERRIER, D. J.
The combined release and radiation effects satellite, a joint NASA/DOD program
p 131 N88-10851

BERRY, MAGGIE L.
Method of radiographic inspection of wooden members
[NASA-CASE-LAR-13724-1]
p 149 N88-23983

BERRY, ROBERT L.
Method of radiographic inspection of wooden members
[NASA-CASE-LAR-13724-1]
p 149 N88-23983

BERRY, THOMAS
Orbital Spacecraft Consumables Resupply System
p 122 A88-15292

BERSON, M.
Cardiovascular adaptation to zero-g during a long term flight (237 days) on board the Salyut 7 Soviet space station (1984)
p 158 N88-19920
Cardiac and peripheral circulation assessment by ultrasound on 3 astronauts during two 7-day space flights (1982 Salyut-7 - 1985 STS 51G)
p 158 N88-19921

BERT, CHARLES W.
Recent advances in dynamics of composite structures
p 19 A88-31427

BERTSCH, P. JEFF
ITDS - A program for interactive design and analysis of advanced active thermal control systems
[SAE PAPER 871421]
p 34 A88-21085

BERUTO, ENRICO
Columbus pressurized modules - A challenging opportunity for microgravity research and application
[IAF PAPER 87-375]
p 137 A88-16050

BETTOJA, FRANCESCO
Trends to reduce development and operation costs for experiments of the future space laboratory
[IAF PAPER 87-100]
p 103 A88-15871

BEVILACQUA, F.
Tethered space elevator - Possible applications and demonstrative experiments
[IAF PAPER 87-49]
p 109 A88-15834
Tethered space system - A new facility for experimental rarefied gas dynamics
p 111 A88-16858

BHATTACHARYYA, S. K.
Monolithic fuel cell based power source for burst power generation
p 71 A88-22691

BHATTI
Development of the Extendable and Retractable Mast (ERM). Design phase 2. Volume 1
[RP-2010-0000-DS/09]
p 31 N88-19750

BIALLA, PAUL
The space based OTV and the establishment of the next launch site
[IAF PAPER 87-196]
p 149 A88-15833

BICKNELL, B.
Space station integrated propulsion and fluid system study. Fluid systems configuration databook
[NASA-CR-179215]
p 79 N88-11753

BIEFELD, ERIC W.
PLAN-IT - Knowledge-based mission sequencing
p 7 A88-21644

BIELAK, J.
Transient response of joint dominated space structures - A new linearization technique
[AIAA PAPER 88-2360]
p 24 A88-32325

BIGLARI, H.
Automated testing and integration of heterogeneous systems
p 33 A88-11874

BIRBARA, P. J.
A smoke removal unit
[SAE PAPER 871449]
p 153 A88-21109

BIRUR, G. C.
Solar dynamic heat receiver thermal characteristics in low earth orbit
[AIAA PAPER 88-0472]
p 71 A88-22348

BJORDAL, J.
AURIO: A proposal for flying auroral imaging observatory on the Polar Platform in the Space Station/Columbus program
p 119 N88-16268

BLACK, DAVID C.
Science on Space Station
p 2 A88-21588

BLACK, RICHARD E.
Research opportunities in microgravity science and applications during Shuttle hiatus
p 108 A88-13164

BLACKWELL, C. C.
Lyapunov function gradient generated robust control in the absence of the nominal stabilizing control
p 54 A88-27404

BLACKWOOD, GARY H.
Experimental component mode synthesis of structures with sloppy joints
[AIAA PAPER 88-2411]
p 24 A88-32339

BLAGOV, V. D.
Blagov commentary on Mir station, first manning
p 144 N88-10951

BLAIS, Y.
Utilization of SMS and EVA for the servicing of European Space Station
p 147 N88-19500

BLAIS, TH.
Control of in-orbit space manipulation
p 91 A88-16312
Robotic sensors and actuators for a service manipulator system. Volume 1: Executive summary
[MATRA-EPT/DT/VT187/120]
p 87 N88-10341
Robotic sensors and actuators for a service manipulator system. Volume 2: Service Manipulator System (SMS) handbook
[MATRA-EPT/DT/VT187/227]
p 87 N88-10342
Robotic sensors and actuators for a service manipulator system. Volume 3, phase A report and program plan
[MATRA-EPT/DT/VT187/229]
p 87 N88-10343
Utilization of robotics and teleoperation for future in-orbit operations
p 93 N88-19527

BLANK, G. E.
Focus of attention in systems for visual monitoring of experiments
p 112 A88-21658

BLANKENSHIP, CHARLES P.
Large space structures - Structural concepts and materials
[SAE PAPER 872429]
p 17 A88-30999
Structures and materials technology for Space Station
[AIAA PAPER 88-2446]
p 17 A88-31377

BLINOV, A. P.
Motion perturbations of a dumbbell in a central Newtonian force field
p 47 A88-11235

BLOCK, ROGER F.
Prototype space station automation system delivered and demonstrated at NASA
p 45 N88-16442

BLYTHE, P. A.
EVA, the technological challenge
p 129 N88-19535

BOCKRIS, J. OM.
Electrochemical processing of solid waste
[NASA-CR-182413]
p 157 N88-15852

BOECK, H.-J.
Columbus Simulation Facility (CSF)
p 148 N88-19522

BOGUS, K.
Environmental interactions of solar generators in space
p 72 N88-11730

BOND, ALAN
Concept studies for a laser powered Orbital Transfer Vehicle
[IAF PAPER 87-200]
p 77 A88-15937

BOND, ROBERT A.
Concept studies for a laser powered Orbital Transfer Vehicle
[IAF PAPER 87-200]
p 77 A88-15937

BONDE-PETERSEN, F.
Scientific objectives and functional requirements of life sciences in the Space Station
p 158 N88-16264

BONDE-PETERSEN, FLEMMING
Scientific objectives and functional requirements of life sciences in the Space Station
p 154 A88-21576

BONIFAZI, C.
Electrical current flow across the TSS - The core equipment and other related technical issues
[IAF PAPER 87-252]
p 109 A88-15871
Laboratory simulation of the electrodynamic interactions of a tethered satellite with an ionospheric plasma
[IFSI-86-3]
p 119 N88-15823

BONITO, N. A.
Analysis of geophysical data bases and models for spacecraft interactions
[AD-A184939]
p 100 N88-13375

BONTING, S. L.
Animal research on the Space Station
p 159 N88-19964

BONTING, SJOERD L.
Need, utilization, and configuration of a large, multi-G centrifuge on the Space Station
p 155 A88-29140

BONLASTA, F.
Columbus preparatory program. Payload element study on a technology demonstration mission, executive summary
[CS-RP-AI-016]
p 145 N88-10080

BOSHE, C.
Design concepts for bioreactors in space
p 45 N88-17179

BOSLEY, J.
Telescience testbedding for life science missions on the Space Station
[AIAA PAPER 88-0446]
p 86 A88-22332

BOSLEY, JOHN J.
OSSA Space Station waste inventory
[SAE PAPER 871413]
p 39 A88-21078

BOSTIC, SUSAN
Three parallel computation methods for structural vibration analysis
[AIAA PAPER 88-2391]
p 24 A88-32323

BOUQUET, D. L.
Carbon Dioxide observational platform system (CO-OPS): Feasibility Study
[NASA-CR-179225]
p 119 N88-14113
Feasibility study of a carbon dioxide observational platform system. Volume 2: Programmatics
[NASA-CR-180404]
p 119 N88-14114

BOWDEN, MARY
Effect of joint damping and joint nonlinearity on the dynamics of space structures
[AIAA PAPER 88-2480]
p 57 A88-32362

BOWDEN, MARY L.
Structural Assembly Demonstration Experiment (SADE)
[NASA-CR-179209]
p 26 N88-10868
Experimental assembly of structures in EVA: Hardware morphology and development issues
p 26 N88-10872

BOWLES, D. E.
Response of composite materials to the Space Station orbit environment
[AIAA PAPER 88-2476]
p 95 A88-31390

BOWLES, KENNETH J.
Mechanical properties characterization of composite sandwich materials intended for space antenna applications
[NASA-TM-88893]
p 25 N88-10121

BOYDA, ROBERT B.
Initial results of integrated testing of a regenerative ECLSS at MSFC
[SAE PAPER 871454]
p 41 A88-21114

BOYS, RANDY M.
A human performance modelling approach to intelligent decision support systems
p 90 N88-17242

BRAAK, L.
Biomedical payload of the French-Soviet long duration flight
[IAF PAPER 87-541]
p 152 A88-16159

BRADFORD, R. K.
Study of large solar arrays (SOLA), phase 2A
[BAE-SS/1109]
p 74 N88-17106

BRADLEY, W.
Preliminary analysis of an integrated logistics system for OSSA payloads
[NASA-CR-4114]
p 6 N88-19477
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 1: Executive summary
p 6 N88-19478
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 2: OSSA integrated logistics support strategy
p 6 N88-19479
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 3: OSSA integrated logistics support planning document
p 6 N88-19480
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 4: Supportability analysis of the 1.8m centrifuge
p 6 N88-19481

BRADSHAW, T. W.
SAFIRE - A novel high resolution cooled spectrometer for atmospheric research
[IAF PAPER 87-137] p 159 A88-15894
BRADY, JOYCE A.
Oxidation and protection of fiberglass-epoxy composite masts for photovoltaic arrays in the low Earth orbital environment
[NASA-TM-100839] p 97 N88-18734
BRAGINA, M. P.
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment
p 145 N88-12917
BRAMBATI, GUALTIERO
Columbus pressurized modules - A challenging opportunity for microgravity research and application
[IAF PAPER 87-375] p 137 A88-16052
BRANDT, GUENTHER
Evolution of data management systems from Spacelab to Columbus
[MBB-UR-E-068-87] p 99 A88-23981
BRANEGAN, J.
Listening to the cosmonauts p 75 A88-13975
Simple analysis of Space Station downlinks
p 150 A88-30189
BRANETS, V. N.
Development experience of the attitude control system using single-axis control moment gyros for long-term orbiting space stations
[IAF PAPER 87-04] p 48 A88-15804
BRAUN, H.-M.
X-band SAR for a European remote sensing payload
p 117 N88-12142
BRAUN, ROBERT D.
Aeroassisted orbit transfer vehicle trajectory analysis
[NASA-TM-89139] p 62 N88-19575
BREKKE, A.
AURO: A proposal for flying auroral imaging observatory on the Polar Platform in the Space Station/Columbus program p 119 N88-16268
BREUS, TAMARA
X-ray astronomy instruments to operate on Mir station
p 144 N88-10052
BRIDGES, FRANK
Planetary science p 5 N88-19358
BRIEHL, DANIEL
Magnetic emissions testing of the space station engineering model resistojet
[NASA-TM-100786] p 91 N88-17728
BRIENS, GUY
Looking ahead for materials and processes. Proceedings of the Eighth SAMPE (European Chapter) International Conference, La Baule, France, May 19-21, 1987
p 94 A88-20701
BRILEY, G. L.
Space station propulsion technology: Space station propulsion system test bed test plan
[NASA-CR-179201] p 78 N88-10104
Space station propulsion technology
[NASA-CR-179260] p 80 N88-15835
BRISCOE, H. W.
Why mechanisms are critical to spacecraft performance p 90 N88-16737
BRITT, DANIEL L.
Power and resource management scheduling for scientific space platform applications
p 106 A88-11980
BROENSTAD, K.
AURO: A proposal for flying auroral imaging observatory on the Polar Platform in the Space Station/Columbus program p 119 N88-16268
BROOME, TAFT H.
Nondestructive construction error detection in large space structures
[AIAA PAPER 88-2480] p 19 A88-31383
BROWDER, A. M.
A general approach to modal analysis for time-varying systems
[AIAA PAPER 88-2256] p 23 A88-32296
BROWN, HARLAN D.
Inflight microbial analysis technology
[SAE PAPER 871493] p 42 A88-21147
BROWN, RICHARD F.
Design of an ammonia two-phase Prototype Thermal Bus for Space Station
[SAE PAPER 871506] p 35 A88-21152
BROWN, WILLIAM C.
Space based nuclear-microwave electric propulsion
p 78 A88-22708
BROWN, WILLIAM W.
Hubble Space Telescope servicing - Experience base for a new era
[IAF PAPER 87-36] p 109 A88-15829
BROWNING, R.
Assembling, maintaining and servicing Space Station
[IAF PAPER 87-60] p 123 A88-15859
BROWNING, RONALD K.
Space Station accommodation of attached payloads
[IAF PAPER 87-97] p 103 A88-15868
BRUCKNER, A. P.
Ram accelerator direct launch system for space cargo
[IAF PAPER 87-211] p 162 A88-15944
BRUDER, R.
On a knowledge based assistant system for highly autonomous control of experiment-manipulators in the Man-Tended Free Flyer p 92 N88-19505
BRUHNE, K.
Remote manipulation in orbital construction, servicing and repair missions: Is one arm enough? A comparative evaluation of the performance features of robots with one or more arms p 93 N88-19509
A comparative survey of mathematical models for dynamic simulation of in-orbit manipulation operations
p 148 N88-19533
BRYANT, D.
AURO: A proposal for flying auroral imaging observatory on the Polar Platform in the Space Station/Columbus program p 119 N88-16268
BUCHA, ROBERT M.
Materials selection as related to contamination of spacecraft critical surfaces p 95 A88-29365
BUDEN, DAVID
Space power needs and technological technologies for the 1990s and beyond p 71 A88-22677
BUECKER, H.
Radiation problems with the Space Station scenario and the necessary surveillance for astronauts
[IAF PAPER 87-542] p 129 A88-16160
Support of life science research in space by the DFVLR Microgravity User Support Center (MUSC)
[IAF PAPER 87-544] p 152 A88-16162
Radiation problems in manned space flight with a view to the Space Station p 132 N88-19934
BUGBEE, BRUCE G.
Space farming in the 21st century
p 106 A88-29237
BUKOWSKI, RICHARD W.
Techniques for fire detection p 156 N88-12521
BULL, RICHARD J.
Toxicological aspects of water recycle and disinfection
[SAE PAPER 871491] p 42 A88-21145
BULL, S. M.
Power requirements for an orbiting space farm
[IAF PAPER 87-242] p 70 A88-15969
BULLOCK, CHRIS
Columbus takes shape - Europe's Space Station approaches decision time p 132 A88-10878
Japan - Future space samurai? p 136 A88-16223
BURCHETT, RAY
Recent developments in water quality monitoring for Space Station reclaimed wastewaters
[SAE PAPER 871447] p 40 A88-21107
BURG, MARTIN
Advanced materials technology '87. Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr 6-9, 1987
p 1 A88-13126
BURKE, KENNETH A.
Static feed electrolyzer technology advancement for space application
[SAE PAPER 871450] p 40 A88-21110
BURKE, W. R.
Report on the scientific satellites of the European Space Agency
[ESA-SP-1080] p 116 N88-10091
BURT, WILLIAM W.
SAMSS: An in-progress review of the Spacecraft Assembly, Maintenance, and Servicing Study
p 127 N88-15890
BURTON, W. T.
Development of the Mast Flight System linear dc motor inertial actuator
[AAS PAPER 87-021] p 13 A88-16090
BUSCH, D. E.
Monolithic fuel cell based power source for burst power generation p 71 A88-22691
BUSH, HAROLD G.
Astronaut/EVA construction of Space Station
[AIAA PAPER 88-0458] p 125 A88-21382
BUSH, JOY
The resource envelope as a basis for space station management system scheduling p 102 N88-16427
BUTNER, C. L.
Tethers in space handbook
[NASA-CR-181971] p 118 N88-14123
BUTNER, CYRUS L.
GEO platform servicing - Technology solutions
[IAF PAPER 87-06] p 122 A88-15808
BUTOV, V. V.
Stratospheric luminescence observed from the Salyut-7 station p 144 A88-30078
BUTTERFIELD, A. J.
Analysis of a rotating advanced technology space station for the year 2025
[NASA-CR-178345] p 157 N88-19580
BUZZARD, GREGORY D.
Translation and execution of distributed Ada programs - Is it still Ada? p 7 A88-21643
BYERS, R. M.
Feedback control design for smooth, near minimum time rotational maneuvers of flexible spacecraft
[AIAA PAPER 88-0671] p 51 A88-22501
BYRD, JIM
Prototype resupply scheduler p 9 N88-16426

C

CABLE, D. A.
Concept definition study for recovery of tumbling satellites. Volume 1: Executive summary, study results
[NASA-CR-179229] p 127 N88-14118
CALDICHOURY, M.
Evaluation of control concepts for a large geostationary data relay satellite p 50 A88-16281
CALEDONIA, GEORGE E.
Shuttle experiments to measure the optical environments surrounding large space structures
[AIAA PAPER 88-0432] p 14 A88-22321
CALICO, ROBERT A.
Structural design and decoupled control
[IAF PAPER 87-319] p 48 A88-16016
CALLOWAY, R. L.
The Aeroassist Flight Experiment
[IAF PAPER 87-197] p 2 A88-15834
CAMPAN, R.
Cosmonaut behaviour in orbital flight situation - Preliminary ethological analysis
[IAF PAPER 87-539] p 152 A88-16151
CAMPBELL, WILLIAM A., JR.
Outgassing data for selecting spacecraft materials
[NASA-RP-1124] p 95 N88-10117
CANDIDI, M.
Mechanical design of the ac bracket package for the PETE experiment
[IFSI-87-4] p 145 N88-13379
PETE experiment Assembly, Integration, and Verification (AIV) activities
[IFSI-87-6] p 117 N88-13380
CANFIELD, R. A.
Optimum design of structures with multiple constraints
p 16 A88-29042
CANN, CHRISTOPHER E.
Bones and stones in space - Integrating the medical and scientific questions
[SAE PAPER 871485] p 153 A88-21123
CANNON, R. H., JR.
Experiments in advanced control concepts for space robotics - An overview of the Stanford Aerospace Robotics Laboratory
[AAS PAPER 87-044] p 63 A88-16908
CAPITANI, GLORIA
Integrated control of large flexible structures
p 16 A88-29474
CAPOBIANCHI, R.
EURECA - An expert system for the management of experiments to be performed on a free-flying platform
[IAF PAPER 87-29] p 135 A88-15821
CARASSO, A. S.
Dynamic characterization of structures by pulse probing and deconvolution
[AIAA PAPER 88-2230] p 21 A88-32193
CARDIERI, L. VICTOR C.
Construction aspects of testbeds for attitude control systems simulation of artificial satellites
[INPE-4283-PRE/1155] p 61 N88-18618
CAREY, WILLIAM C.
Progress toward a cosmic dust collection facility on space station
[NASA-CR-183407] p 101 N88-19588
CARLI, B.
SAFIRE - A novel high resolution cooled spectrometer for atmospheric research
[IAF PAPER 87-137] p 159 A88-15894
CARLISLE, RICHARD F.
United States Space Station technical and programmatic interfaces
[IAF PAPER 87-45] p 162 A88-15844
CARLOMAGNO, GIOVANNI M.
Low density aerothermodynamics studies performed by means of the tethered satellite system
p 111 A88-16823
Downward-deployed tethered platforms for high enthalpy aerothermodynamic research
[AIAA PAPER 88-0668] p 114 A88-22514

CARLSON, ALBERT
Heat pipe radiators for solar dynamic space power system heat rejection p 33 A89-11907
CARLSON, ALBERT W.
High thermal-transport capacity heat pipes for space radiators
[SAE PAPER 871509] p 35 A89-21156
CARLSON, L. W.
Monolithic fuel cell based power source for burst power generation p 71 A89-22691
CARNES, JAMES R.
FMEAssist: A knowledge-based approach to Failure Modes and Effects Analysis p 101 N89-16395
Foundation: Transforming data bases into knowledge bases p 102 N89-16423
CAROSSO, NANCY J. P.
Assessment of external contamination for Space Station scientific payloads
[SAE PAPER 871476] p 130 A89-21131
CARRASQUILLO, R. L.
The Space Station air revitalization subsystem design concept
[SAE PAPER 871446] p 40 A89-21109
CARSON, RALPH
Advanced materials technology '87; Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr 6-9, 1987
p 1 A89-13126
CARTER, DELAND R.
Pointing mount with active vibration isolation for large payloads
[AAS PAPER 87-033] p 103 A89-16943
CARTER, J.
AURIO: A proposal for flying auroral imaging observatory on the Polar Platform in the Space Station/Columbus program p 119 N89-16268
CARTER, W. D.
Remote sensing Earth's surface and atmosphere; Proceedings of Workshop X and the Topical Meeting of the 26th COSPAR Plenary Meeting, Toulouse, France, June 30-July 11, 1986 p 111 A89-17026
CARTER, WILLIAM D.
Earth science missions for the Space Station
p 111 A89-17039
CARTWRIGHT, T. J.
EVA, the technological challenge p 126 N89-19535
CARVELL, R. P.
A packetized remote visual access data system for Space Station interactive payload operations
p 99 A89-21253
CASTILLO, D.
An AI approach for scheduling space-station payloads at Kennedy Space Center p 90 N89-16425
CATHCART, J. A.
Concept definition study for recovery of tumbling satellites. Volume 1: Executive summary, study results
[NASA-CR-179728] p 127 G3-14119
CECKA, JOSEPH R.
Use of a distributed microprocessor network for control of the Space Station electrical power system
p 67 A89-11956
CEPOLLINA, F. J.
Technology advancements for servicing of future spacecraft systems
[IAF PAPER 87-36] p 102 A89-15826
CHAIT, YOSSI
Control of distributed parameter systems with spillover using an augmented observer p 16 A89-27377
CHALONER, C.
AURIO: A proposal for flying auroral imaging observatory on the Polar Platform in the Space Station/Columbus program p 119 N89-16268
CHAMBERS, MARETA W.
An application of MSC/NASTRAN in the interdisciplinary analysis of large space-based structures
p 17 A89-29819
CHAMBLISS, JOE P.
ITDS - A program for interactive design and analysis of advanced active thermal control systems
[SAE PAPER 871471] p 34 A89-21095
CHANDLER, PHILIP
The Columbus programme - European steps towards the considered development of near-earth space
p 139 A89-19835
CHANG, C. W.
A finite element method for time varying geometry in multibody structures
[AIAA PAPER 88-2334] p 21 A89-32187
CHANG, KAI-HSIUNG
Planning activities in space p 9 N89-16417
CHAPEL, JIM D.
Stability analysis for alternative force control schemes as applied to remote space teleoperation
[AAS PAPER 87-043] p 51 A89-16368
CHAPPE, A.
Biomedical payload of the French-Soviet long duration flight
[IAF PAPER 87-541] p 152 A89-19158
CHAPPELL, CHARLES R.
Solar-terrestrial research in the space station era
p 116 N89-10747
CHARLTON, J. E.
Study of a payload for Columbus Polar Platform Earth observation demonstration mission, executive summary
[ESA-CR(P)-2412] p 116 N89-10079
CHASSAY, CHARLES
A monograph of the National Space Transportation System Office (NSTSO) integration activities conducted at the NASA Lyndon B. Johnson Space Center for the EASE/ACCESS payload flown on STS 61-B
p 27 N89-10876
CHASSIAKOS, A. G.
On the modeling and control of a flexible manipulator arm by joint actuators p 62 A89-14996
CHAUDOIR, D.
The evolution of space power systems technology
[IAF PAPER 87-226] p 68 A89-15952
CHELLINGSWORTH
Development of the Extendable and Retractable Mast (ERM). Design phase 2: Volume 1
[RP-2010-0000-DS-09] p 31 N89-16750
CHEN, GUN-SHING
Passive damping for space truss structures
[AIAA PAPER 88-2469] p 24 A89-32300
CHENG, J.
On the hierarchical control of the Space Station common module thermal system p 33 A89-14980
CHERRETTE, A. R.
Compensation of reflector antenna surface distortion using an array feed
[NASA-TM-100286] p 77 N89-16805
CHERTOK, B.
Gyrostabilizer system of Kvant module
p 60 N89-16099
CHETTY, P. R. K.
Electrical power system for low earth orbit spacecraft applications p 65 A89-11917
CHEW, MENG-SANG
Assessment of the COFS/MAST I project
[NASA-CR-181366] p 25 N89-10040
CHIARELLI, C.
Tethered space system - A new facility for experimental rarefied gas dynamics p 111 A89-15858
CHIEN, PHILIP
Assembling the Space Station p 123 A89-20475
CHILIN, IURII NIKOLAEVICH
Optimization of the energy systems of manned orbital stations - Mathematical modeling and selection of efficient structures p 68 A89-15864
CHIOU, W. C., SR.
Cooperating expert systems for Space Station power distribution management p 71 A89-21633
CHIOU, WUN C., SR.
Space Station automation II; Proceedings of the Meeting, Cambridge, MA, Oct. 29-30, 1986
[SPIE-729] p 94 A89-21631
CHOBOTOV, V. A.
Dynamics of orbital debris clouds and the resulting collision hazard to spacecraft
[IAF PAPER 87-571] p 129 A89-16182
CHOSNOT, M.
The Spacebus platforms
[AIAA PAPER 88-0775] p 115 A89-27535
CHOUDRY, A.
Goal driven kinematic simulation of flexible arm robot for space station missions p 89 N89-16388
Solid modelling for the manipulative robot arm (power) and adaptive vision control for space station missions
p 89 N89-16409
CHOW, L. C.
Fluid loss from a puncture of a space radiator
p 72 A89-30017
CHRETIEN, J. P.
Automatic control in space 1985 p 50 A89-16276
Modelling and simulation of distributed flexibility in a spaceborne manipulator p 83 A89-16309
Identification and control of flexible structures
p 54 A89-27768
CHUBB, DONALD L.
Performance characteristics of a combination solar photovoltaic heat engine energy converter
p 65 A89-11913
CHUN, HON M.
Large-angle slewing maneuvers for flexible spacecraft
[NASA-CR-4123] p 60 N89-16080
CIANCONE, MICHAEL L.
Oxidation and protection of fiberglass-epoxy composite masts for photovoltaic arrays in the low Earth orbital environment
[NASA-TM-100839] p 97 N89-16734
Mast material test program (MAMATEP)
[NASA-TM-100821] p 31 N89-19592
CIARDO, S.
Tethered space elevator - Possible applications and demonstrative experiments
[IAF PAPER 87-49] p 109 A89-15834
CIARLO, A.
Application of expert systems for satellite autonomy
p 90 N89-16443
CIRILLO, WILLIAM
Space station accommodations for lunar base elements: A study
[NASA-TM-100501] p 106 N89-14307
CITARELLA, LUIGI
Legal problems of the commercial use of space stations including proprietary rights p 160 A89-13452
CITRON, ROBERT
Spacehab - A manned Space Station testbed
p 103 A89-15267
Space Station habitat and laboratory module rack flight testing in the Spacehab Module
[SAE PAPER 871416] p 103 A89-21090
On-orbit servicing enhancements with Crewlock EVA operations from the Spacehab module
[SAE PAPER 871496] p 40 A89-21148
The Spacehab module passive thermal control
[SAE PAPER 871508] p 34 A89-21154
CLAAR, T. D.
Monolithic fuel cell based power source for burst power generation p 71 A89-22691
CLANCY, P.
Microgravity payloads and missions for Space Station: Some issues affecting compatibility with other payloads
p 120 N89-16793
CLARK, B. C.
Feasibility study for gas-grain simulation facility
[NASA-CR-177468] p 28 N89-13954
CLARK, BENTON C.
Human exploration of Mars
[AIAA PAPER 88-0164] p 105 A89-22044
CLARK, PHILLIP S.
Soyuz enters third decade p 134 A89-16700
CLARKE, ANTONY
Atmospheric science p 5 N89-15357
CLARKE, M. M.
An orbiting control station for free-flying teleoperators - Preliminary design methodology p 51 A89-21647
CLARKE, MARGARET M.
Manipulator arm design for the Extravehicular Teleoperator Assist Robot (ETAR): Applications on the space station p 91 N89-17270
CLAUDINON, B.
Control techniques for rendez-vous and docking
p 51 A89-18311
Rendezvous and docking (RVD) verification and demonstration in-orbit p 62 N89-19531
CLAUNCH, WILLIAM C.
Technology demonstrator program for Space Station Environmental Control Life Support System
[SAE PAPER 871456] p 41 A89-21115
CLEARWATER, YVONNE A.
Human factor design of habitable space facilities
[IAF PAPER 87-549] p 38 A89-18188
CLEARY, ANDREW
Solution of structural analysis problems on a parallel computer
[AIAA PAPER 88-2267] p 22 A89-32240
CLEMENT, G.
Robotic sensors and actuators for a service manipulator system. Volume 1: Executive summary
[MATRA-EPT/DT/VT187/120] p 87 N89-10341
Robotic sensors and actuators for a service manipulator system. Volume 2: Service Manipulator System (SMS) handbook
[MATRA-EPT/DT/VT187/227] p 87 N89-10342
Robotic sensors and actuators for a service manipulator system. Volume 3, phase A report and program plan
[MATRA-EPT/DT/VT187/228] p 87 N89-10343
CLIFFTON, ETHAN WILSON
Space station architectural elements model study: Space station human factors research review
p 102 N89-19884
CLINE, HELMUT P.
Satellite servicing in the Space Station era
p 121 A89-15266
Assembly of user systems at Space Station
p 121 N89-19490
CLIPSON, COLIN W.
Full scale architectural simulation techniques for space stations p 10 N89-19887
COCHRAN, J. E., JR.
An investigation of the damping phenomena in wire rope isolators p 21 A89-31597
COCHRAN, THOMAS H.
Space Station Electrical Power System
[IAF PAPER 87-224] p 69 A89-15958

COGGER, L. L.
AURIO: A proposal for flying auroral imaging observatory on the Polar Platform in the Space Station/Columbus program p 118 N89-14268
COGOLI, A.
Space biologist's inflight safety considerations [IAF PAPER 87-570] p 153 A88-16182
COHEN, AARON
Use of automation and robotics for the Space Station p 84 A89-21632
COHEN, HERBERT A.
The effect of photoelectrons on boom-satellite potential differences during electron beam ejection [AD-A190390] p 75 A88-20350
COHEN, LESTER M.
Design, analysis, fabrication and test of the LAMAR prototype mirror assembly p 10 A88-12719
COLE, MATTHEW B.
Space station internal environmental and safety concerns p 156 N89-12527
COLES-HAMILTON, CAROLYN
Selection of high temperature thermal energy storage materials for advanced solar dynamic space power systems p 64 A88-11801
COLES-HAMILTON, CAROLYN E.
Impact of thermal energy storage properties on solar dynamic space power conversion system mass p 64 A88-11805
COLLADAY, RAYMOND S.
Technology - The basis for the past, the key to the future [IAF PAPER 87-47] p 161 A88-15833
COLOMBINA, G.
In-orbit automatic assembly of reticular structures p 92 N89-19491
COLOMBO, GERALD V.
Review of water disinfection techniques [SAE PAPER 871468] p 42 A89-21142
COLWELL, GENE T.
Development of an emulation-simulation thermal control model for space station application [NASA-CR-182409] p 37 N89-15823
COMANDATORE, EMANUELE
Columbus pressurized module verification p 145 N89-10842
COMPOSTIZO, C.
Robotics servicing experiment p 93 N89-19529
CONCHIE, P. J.
The Columbus polar platform p 140 A89-21358
CONTET, J.
Study of fault tolerant techniques for satellite data handling [FTT/REP/0501/SAAB] p 101 N89-13980
CONWAY, BRUCE A.
Spaceborne optical disk controller development p 98 A89-12755
NASA spaceborne optical disk recorder development p 100 A89-29620
CONWAY, E. J.
Preliminary conceptual design and weight of a one-megawatt space-based laser power station utilizing a solar-pumped iodine lasant p 65 A89-11916
COOMBS, MURRAY G.
Solar receiver for the Space Station Brayton engine [ASME PAPER 87-GT-252] p 62 A89-11134
COOPER, PAUL A.
An application of MSC/NASTRAN in the interdisciplinary analysis of large space-based structures p 17 A89-23619
Dynamics and control characteristics of a reference Space Station configuration [AIAA PAPER 88-2485] p 55 A89-31394
COPPA, ANTHONY P.
A general truss system for very large space base foundations, with application to the solar power satellite [IAF PAPER 87-249] p 11 A89-10967
CORBIN, S. D.
Animal research on the Space Station p 159 N89-19984
CORNET, J.
Operational utilization of the polar platforms [IAF PAPER 87-116] p 159 A89-15982
CORONADO, A. R.
Space Station probability of no penetration due to meteoroid and orbital debris impact [AIAA PAPER 88-2484] p 18 A89-31387
Space station integrated wall design and penetration damage control [NASA-CR-179166] p 25 N89-10070
CORONADO, ALEX R.
Hypervelocity impact damage assessment for Space Station [AIAA PAPER 88-2485] p 18 A89-31388
CORRIGAN, ROBERT D.
Solar concentrator advanced development project p 64 A89-11799
CORTINOVIS, R.
Study of a payload for Columbus Polar Platform Earth observation demonstration mission, executive summary [ESA-CR(P)-2412] p 118 N89-10079
Robotic intelligence issues for space manipulator monitoring, control programming p 92 N89-19504
COSMOVICI, C.
Laboratory simulation of the electrodynamic interactions of a tethered satellite with an ionospheric plasma [IFSI-88-3] p 119 N89-13822
COSTABAGNA, LAZZARO
Thermal control definition of Columbus pressurized modules [SAE PAPER 871483] p 139 A89-21138
The Spacehab module passive thermo control [SAE PAPER 871508] p 35 A89-21154
COTTRELL, K. G.
Analyses of geophysical data bases and models for spacecraft interactions [AD-A184859] p 100 N88-13375
COUGNET, C.
Long-term evolution toward European manned spaceflight [IAF PAPER 87-78] p 136 A89-15853
Space Station logistic support by Ariane [IAF PAPER 87-227] p 137 A89-15950
Assembly and servicing of a European Space Station p 147 N89-19492
Utilization of SMS and EVA for the servicing of European Space Station p 147 N89-19500
CRAMAROSSA, A.
Study of mobile communications payload for Columbus Polar Platforms [ITS-TR-056A/96] p 76 N89-10220
CRANZ, GALEN
Social factors in space station interiors p 46 N89-19868
CREASY, W.
Assembling, maintaining and housing Space Station [IAF PAPER 87-85] p 123 A89-15859
CRITCHFIELD, ANNA
The resource envelope as a basis for space station management system scheduling p 102 N89-19427
CROCKER, W. J.
Experimental study of damping of graphite epoxy composite material of the Space Telescope truss system p 56 A81-31805
CRONE, MICHAEL
CAMERA: Expert System for Space Station communications and tracking system management p 75 A89-15283
CROOM, DAVID L.
Earth observation and the Space Station p 112 A89-[illegible]
CROSS, J. B.
High intensity 5 eV O-atom exposure facility for material degradation studies p 96 N89-10847
CROUSE, K. R.
An approach to design knowledge capture for the space station p 7 A89-21842
Design knowledge capture for the space station p 9 N89-17239
CRUSE, T. A.
Long-life assurance for Space Station - Is it an issue? [AIAA PAPER 88-2489] p 43 A89-31398
CUCCIA, LOUIS
Communication satellite technology trends p 76 N89-10088
CUDDIHY, W. F.
Analysis of a rotating advanced-technology space station for the year 2025 [NASA-CR-179345] p 107 N89-19580
CUFFIN, S. M.
Space station onboard propulsion system Technology study [NASA-CR-179233] p 60 N89-15006
CULP, ROBERT D.
Guidance and control 1987; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Jan. 31-Feb. 4, 1987 p 51 A89-16976
CUNNAN, G.
Water management requirements for animal and plant maintenance on the Space Station [SAE PAPER 871468] p 41 A89-21125
CUNNAN, GEORGE L.
ORSA Space Station waste inventory [SAE PAPER 871413] p 39 A89-21078
CUNICK, R. J.
Electrochemically regenerable carbon dioxide/moisture control technology for an Advanced Extravehicular Mobility Unit [SAE PAPER 871470] p 41 A89-21126
CUNICK, ROBERT J.
Development of a regenerable humidity and CO2 control system for an advanced EMU [SAE PAPER 871471] p 41 A89-21127
CUTCHINS, M. A.
An investigation of the damping phenomena in wire rope isolators p 21 A88-31597
CUTTS, DIANNE E.
FMEAssist: A knowledge-based approach to Failure Modes and Effects Analysis p 101 N89-16305
Foundation: Transforming data bases into knowledge bases p 102 N89-19423
CZAJKOWSKI, EVA A.
Spillover stabilization of large space structures [AIAA PAPER 88-2484] p 55 A89-31393

D

D'ARCY, ANDREW J.
Video-based satellite attitude determination p 51 A89-21657
D'EMILIANO, L.
Columbus: Attached Pressurized Module configuration - MTFF Pressurized Module configuration p 134 A89-15298
DABBS, JOSEPH
The X-ray large array II - Implementation [AIAA PAPER 88-0654] p 14 A89-22488
DALBELLO, RICHARD
National jurisdiction on the Space Station p 160 A89-13400
DALEY, PHILIP C.
Autonomous spacecraft operations - Problems and solutions [AIAA PAPER 87-2950] p 61 A89-12571
DAME, L.
A test bed for space interferometry: Space Platform interferometer (SPI) p 5 N88-10640
DARNOVA, T.
Observations of ocean and sea bottom relief from space p 143 A89-26099
DAMILOV-NITUSOV, N. N.
Development experience of the attitude control system using single-axis control moment gyros for long-term orbiting space stations [IAF PAPER 87-04] p 48 A88-15804
DANNENFELSER, ROBERT, JR.
Moving the factory into orbit p 165 N89-10844
DARIVA, I.
A preliminary study of a fluid science laboratory for space station (Columbus): Part 4: Executive summary [NLR-TR-87023-L-PT-4] p 79 N89-11072
DAUGHTREY, RODNEY S.
Intelligent man/machine interfaces on the space station p 90 N89-19418
DAVEY, K.
On the hierarchical control of the Space Station common module thermal system p 33 A88-14980
DAVIES, B.
Preparation of Space Station/Columbus utilization [IAF PAPER 87-85] p 137 A89-15868
DAVIS, BILLY
The X-ray large array II - Implementation [AIAA PAPER 88-0654] p 14 A89-22488
DAVIS, JOHN
The X-ray large array II - Implementation [AIAA PAPER 88-0654] p 14 A89-22488
DAVIS, L. D.
Development of the Mast Flight System linear dc motor inertial actuator [AAS PAPER 87-021] p 13 A88-16890
DAVIS, L. P.
Very high damping in large space structures p 20 A89-31594
DAVIS, L. PORTER
Viscous damped space structure for reduced jitter p 29 N89-13023
DAVIS, NEIL W.
Japan takes charge p 143 A89-27952
DAVIS, R.
In-orbit and laboratory exchange of ORUs designed/not designed for servicing p 151 N89-19439
DAVIS, ROY G.
Intermodule ventilation studies for the Space Station [SAE PAPER 871429] p 130 A88-21091
DAVISON, E. J.
Decentralized control of third generation spacecraft p 15 A89-27358
DE BOSSU, JACQUES
Looking ahead for materials and processes; Proceedings of the Eighth SAMPE (European Chapter) International Conference, La Baule, France, May 18-21, 1987 p 94 A88-20701
DE FILIPPIS, VINCENZO
Columbus pressurized modules: Maintenance and supply concepts - Approach and development for a Space Station long term support [IAF PAPER 87-86] p 137 A89-15860

DE KOOMEN, J. H.
Fokker subsystem responsibilities on Columbus B phase studies p 141 A88-21561
DE LEO, MARIO
Partnership, a key issue in the International Space Station cooperation p 142 A88-21575
DE LUCA, LUIGI
Low density aerothermodynamics studies performed by means of the tethered satellite system p 111 A88-16859
DE YOUNG, R. J.
Preliminary conceptual design and weight of a one-megawatt space-based laser power station utilizing a solar-pumped iodine lasant p 65 A88-11816
DEATON, A. WAYNE
OMV servicing missions from Space Station p 121 A88-15291
DEBARRO, MARC J.
G189 computer program modeling of environmental control and life support systems for the Space Station [SAE PAPER 871427] p 39 A88-21090
DEBAS, G.
Evolution towards an autonomous European manned space infrastructure [IAF PAPER 87-67] p 136 A88-15846
DEBOER, A.
A DMAP for updating dynamic mathematical models with measured data [NLR-MP-86027-U] p 26 N88-10387
DEBRIE, R.
Laboratory simulation of the electrodynamic interactions of a tethered satellite with an ionospheric plasma [IFSI-86-3] p 119 N88-15822
DEBRUYN, J. C.
REPPRE-REPSIM-RePSTA - Programs for evaluating the availability and maintenance of space systems p 125 A88-27778
DEFIGUEIREDO, RUI J. P.
Vision technology/algorithms for space robotics applications p 90 N88-17267
DEGTIAREV, GENNADII LUKICH
Theoretical principles of the optimal control of flexible spacecraft p 47 A88-10050
DEHNER, GERARD F.
Thermoelectric integrated membrane evaporation subsystem testing [SAE PAPER 871446] p 40 A88-21106
DELGADO, HUGO M., JR.
The use of transputers in processing telemetry data p 98 A88-15303
DELIL, A. A. M.
Considerations concerning a thermal joint for a deployable or steerable battery radiator for the Columbus Polar Platform [NLR-TR-86055-U] p 37 N88-11739
DELLI-SANTI, GEORGE T.
Medical aspects of orbital spaceflight and their implications for manufacturing in space p 38 A88-13162
DELPECH, M.
Modeling and simulation of distributed flexibility in a spaceborne manipulator p 83 A88-16309
DELTORO, J.
Robotic sensors and actuators for a service manipulator system. Volume 1: Executive summary [MATRA-EPT/DT/VT187/120] p 87 N88-10341
Robotic sensors and actuators for a service manipulator system. Volume 2: Service Manipulator System (SMS) handbook [MATRA-EPT/DT/VT187/227] p 87 N88-10342
Robotic sensors and actuators for a service manipulator system. Volume 3, phase A report and program plan [MATRA-EPT/DT/VT187/228] p 87 N88-10343
DEMERDASH, NABEEL A. O.
Computer-aided modeling and prediction of performance of the modified Lundell class of alternators in space station solar dynamic power systems [NASA-CR-182539] p 74 N88-19000
DEMING, JESS
Biotechnology opportunities on Space Station [SAE PAPER 871468] p 154 A88-21124
DENINNO, A.
Study of mobile communications payload for Columbus Polar Platforms [ITS-TR-056A/86] p 76 N88-10020
DENNER, W. J.
Collector and receiver designs for high temperature Brayton cycle for space application [IAF PAPER 87-226] p 69 A88-15953
DENONCOURT, PETER J.
Parametrics of nickel-hydrogen cell design p 75 A88-11912
DENTON, JUDITH S.
Third Conference on Artificial Intelligence for Space Applications, part 1 [NASA-CP-2492-Pt-1] p 89 N88-16360
DERIS, JOHN
Fire extinguishment and inhibition in spacecraft environments p 156 N88-12523
DEROCHER, W. L., JR.
Concept definition study for recovery of tumbling satellites. Volume 1: Executive summary, study results [NASA-CR-179228] p 127 N88-14118
DERYDER, L.
Steady state micro-g environment on Space Station [AIAA PAPER 88-2482] p 4 A88-31385
The impact of asymmetric physical properties on large space structures [AIAA PAPER 88-2496] p 19 A88-31395
Orbit lifetime characteristics for Space Station [AIAA PAPER 88-2490] p 55 A88-31399
DERYDER, L. J.
Assessment of mixed fleet potential for space station launch and assembly [NASA-TM-100550] p 107 N88-18608
DESOUZA, PETRONIO N.
Simulation and tests of a satellite attitude and orbit control system. General considerations concerning an example case (INPE) and design of a servo rate table [INPE-4282-PRE/1154] p 62 N88-19572
DETTMER, J.
European retrievable carrier Eureca servicing by Hermes p 139 A88-21256
DEVILLIERS, N.
Payload configurations and serviceability p 117 N88-12133
DEVIRIAN, MICHAEL
Science on the Space Station: The opportunity and the challenge - A NASA view [IAF PAPER 87-92] p 98 A88-15863
DEVOL, WILLIAM
Cryogenic Fluid Management Technology Workshop. Volume 1: Presentation material and discussion [NASA-CP-10001] p 60 N88-15924
DIAMANDIS, PETER H.
Providing artificial gravity - Physiologic limitations to rotating habitats [IAF PAPER 87-545] p 152 A88-16163
DIAZ, ALPHONSO V.
Evolutionary Space Station infrastructure [IAF PAPER 87-103] p 105 A88-15872
DICKEY, BERNISTINE
Life sciences biomedical research planning for Space Station [SAE PAPER 871464] p 153 A88-21122
Biotechnology opportunities on Space Station [SAE PAPER 871468] p 154 A88-21124
DICKINSON, P. H. G.
SAFIRE - A novel high resolution cooled spectrometer for atmospheric research [IAF PAPER 87-137] p 109 A88-15894
DIEDERIKS-VERSCHOOR, I. H. PH.
The applicable legal regime for international cooperation p 160 A88-13448
DILLMANN, R.
Mobile robot activity model for autonomous free flying platforms p 92 N88-19507
DIPPREY, NEIL F.
Orbital Maneuvering Vehicle (OMV) propulsion subsystem [IAF PAPER 87-261] p 149 A88-15976
DIVONA, CHARLES J.
Manipulator arm design for the Extravehicular Teleoperator Assist Robot (ETAR): Applications on the space station p 91 N88-17270
DIXSON, JOHN
Geostationary earth observations - Platform operations from the Space Station [IAF PAPER 87-19] p 108 A88-15814
DIXSON, JOHN E.
Economic benefits of the Space Station to commercial communication satellite operators [IAF PAPER 87-622] p 163 A88-16215
DOBRANICH, D.
The effect of maximum-allowable payload temperature on the mass of a multimegawatt space-based platform [DE88-001921] p 37 N88-13381
DOBRANICH, DEAN
Estimating payload internal temperatures and radiator size for multimegawatt space platforms [DE88-000244] p 37 N88-11738
DOETSCH, K. H.
Assembling, maintaining and servicing Space Station [IAF PAPER 87-85] p 123 A88-15859
Canada's Space Station Program p 142 A88-24980
DOKUCHAEV, L. V.
Rotation stability of a deformable flight vehicle p 144 A88-30115
DOLCE, JAMES L.
An integrated approach to space station power system autonomous control p 67 A88-11853
A systems engineering approach to automated failure cause diagnosis in space power systems p 68 A88-11870
DOLKAS, PAUL
Biosolation on the Space Station - Of mice and men [SAE PAPER 871457] p 153 A88-21116
DOLLERY, A. A.
Past, present and future activities in space power technology in the UK [IAF PAPER 87-243] p 69 A88-1[illegible]464
DONNELLY, ROBERT A.
Development of a graphical display on the DMS test bed p 101 N88-14864
DONZELLI, P.
Applicability of A.I. techniques to the Space Station, a study case - Development of an expert system for on board fault management [IAF PAPER 87-30] p 83 A88-15822
Expert system study for spacecraft management [TL-2699-ISS-1] p 101 N88-15004
Applications of expert systems for satellite autonomy p 90 N88-16443
Robotic intelligence issues for space manipulator monitoring, control programming p 92 N88-19504
DORDAIN, J. J.
The potential of Columbus element utilisation [IAF PAPER 87-94] p 137 A88-15865
DORSEY, K. L.
Optical fiber waveguides for spacecraft applications p 95 A88-21618
DOSYBEKOV, K.
Motion perturbations of a dumbbell in a central Newtonian force field p 47 A88-11235
DOTSON, R. S.
Computing architecture for telerobots in earth orbit p 99 A88-21650
DOWNER, JAMES
Application of magnetic bearings to high-torque, satellite attitude control wheels p 47 A88-11908
DUCHOSSOIS, G.
Polar platform element of Space Station: Mission objectives, European priorities, candidate instrumentation and selection procedure p 119 N88-16779
DUDKIN, V. E.
Determination of cosmic-ray characteristics on Salyut-7 p 131 A88-28349
DUDLEY, W.
Design techniques for 20K Hz power converters p 66 A88-11822
DUGUNDJI, JOHN
Effect of joint damping and joint nonlinearity on the dynamics of space structures [AIAA PAPER 88-2480] p 57 A88-32362
DUKE, M. B.
A lunar laboratory p 156 A88-29196
DULEY, WALTER
Astrophysics and the solar nebula p 118 N88-15355
DUNLOP, E. H.
Design concepts for bioreactors in space p 45 N88-17179
DUNN, B. D.
Advanced materials for ESA spacecraft p 133 A88-13569
DUNN, BRUCE P.
High-energy orbit refueling for orbital transfer vehicles p 150 A88-27887
DUPAS, ALAIN
New space priorities in the USSR p 28 A88-15826
DURSCH, H.
Chromic acid anodizing of aluminum foil [NASA-CR-178417] p 97 N88-15077
DURSCH, HARRY W.
Protective coatings for composite tubes in space applications p 94 A88-13239
DUSCHATKO, R. J.
Space Station body mounted radiator design [SAE PAPER 871507] p 35 A88-21153
DUSTIN, MILES O.
Advanced space solar dynamic power systems beyond IOC Space Station p 64 A88-11798
DUTTO, P.
Operational utilization of the polar platforms [IAF PAPER 87-116] p 109 A88-15882
DUTTO, PIERRE
Coorbitation of free-flyers [IAF PAPER 87-14] p 108 A88-15811
DYER, C. S.
Environmental constraints for Polar Platform design [IAF PAPER 87-09] p 108 A88-15809
DZHANIBEKOV, V. A.
Stratospheric luminescence observed from the Salyut-7 station p 144 A88-30076
DZHINOVA, Z. P.
Space near and far p 143 A88-27734

E

EAGLESON, K. W.
Rapid toxicity detection in water quality control utilizing automated multispecies biomonitoring for permanent space stations p 44 N88-10648
EASTEP, FRANKLIN E.
Structural design and decoupled control
[IAF PAPER 87-318] p 48 A88-16016
EATON, D. C. G.
The use of advanced materials in space structure applications
[IAF PAPER 87-305] p 94 A88-16006
EBARA, K.
Vapor compression distiller and membrane technology for water revitalization p 38 A88-17072
ECKHARDT, R. J.
Analysis of geophysical data bases and models for spacecraft interactions
[AD-A184809] p 100 N88-13375
ECKSTEIN, MARTIN C.
Safe rendezvous approach to a space station by impulsive transfers and continuous thrust arcs p 151 N88-19486
EDWARDS, B. F.
Overview of crew member energy expenditure during Shuttle Flight 61-B EASE/ACCESS task performance p 156 N88-10842
EGAN, JOHN J.
Business issues of materials processing in space p 160 A88-13451
Station pricing - Not just a question of 'How much does it cost?'
[IAF PAPER 87-631] p 163 A88-16223
EGGER, ROBERT A.
Oxidation-resistant reflective surfaces for solar dynamic power generation in near earth orbit p 70 A88-16523
EGGERS, GERT
Electrical power for Columbus - An important cross-element task p 140 A88-21560
EGOROV, A. D.
Man in space flight
[IAF PAPER 87-527] p 162 A88-16150
EHLERS, H.
Space station contamination considerations p 131 N88-10859
EHRESMAN, DERIK T.
Solar concentrator advanced development project p 64 A88-11799
EICHOLD, ALICE
Social factors in space station interiors p 46 N88-10668
EISENHAURE, DAVID
Application of magnetic bearings to high-torque, satellite attitude control wheels p 47 A88-11908
EITELJOERGE, J.
Mobile robot activity model for autonomous free flying platforms p 92 N88-19507
EL-GENK, MOHAMED S.
Space nuclear power systems 1986; Proceedings of the Third Symposium, Albuquerque, NM, Jan. 13-16, 1986 p 71 A88-22676
ELDRED, CHARLES H.
Capture-ejector satellites p 108 A88-11726
ELFVING, A.
Simulation tools for the development of an autonomous rendezvous and docking system p 47 A88-13572
EUROSIM: A design concept for an in-orbit operations simulator p 148 N88-19517
Definition of the EUROSIM simulation subsystem p 148 N88-19532
ELIAS, W. E.
High temperature resistant compliant modified epoxies p 95 A88-29585
ELIASSON, T.
Study of fault tolerant techniques for satellite data handling
[FTT/REP/0001/SAAB] p 101 N88-13860
ELLEMAN, DANIEL E.
Research opportunities in microgravity science and applications during Shuttle hiatus p 108 A88-13164
ENGSTROEM, F.
Columbus, present programme status
[IAF PAPER 87-62] p 135 A88-15841
The Columbus Programme p 140 A88-21555
ERB, DONA M.
Onboard training for the Space Station
[AIAA PAPER 88-0445] p 154 A88-22331
ERCOLI FINZI, A.
Feasibility study of a stabilizer fin for the tethered satellite system p 111 A88-16860
ERICKSON, A. C.
Performance evaluation of SPE electrolyzer for Space Station life support
[SAE PAPER 871451] p 40 A88-21111
ERICKSON, JON D.
Intelligent systems and robotics for an evolutionary Space Station p 86 A88-24239
ERICKSON, W. K.
NASA Systems Autonomy Demonstration Program - A step toward Space Station automation p 84 A88-21639
ERICKSON, WILLIAM K.
MTK: An AI tool for model-based reasoning p 9 N88-16372
ERSFELD, HERMANN
Legal problems in the construction of space stations p 133 A88-13449
ERSUE, E.
A knowledge-based approach for sensory-controlled assembly operations p 126 N88-19506
Definition of the EUROSIM simulation subsystem p 148 N88-19532
A comparative survey of mathematical models for dynamic simulation of in-orbit manipulation operations p 148 N88-19533
ERWIN, HARRY O.
Laser Docking System Radar flight experiment p 47 A88-12914
ERWIN, HARRY O., JR.
An overview of the Office of Space Flight satellite servicing program plan
[IAF PAPER 87-35] p 122 A88-15825
NASA Office of Space Flight (OSF) in-orbit servicing program p 128 N88-19498
ESTES, ROBERT D.
Alfven waves from an electrodynamic tethered satellite system p 115 A88-25690
ETOH, T.
Experimental study for carbon dioxide removal system in Space Station
[SAE PAPER 871516] p 43 A88-21181
EUBANKS, R. A.
Investigation of design concepts for large space structures to support military applications
[AD-A186098] p 29 N88-15000
EVANS, AUSTIN LEWIS
Modeling the performance of the monogroove with screen heat pipe for use in the radiator of the solar dynamic power system of the NASA Space Station
[IAF PAPER 87-238] p 34 A88-15960
EVANS, S. A.
Space station propulsion technology
[NASA-CR-179260] p 80 N88-15835
EVATT, THOMAS C.
Application of advanced automation techniques in the Space Station electrical power system p 75 A88-11855
EWALD, J.
Study on long term evolution towards European manned space flight. Volume 1: Executive summary
[MBB-RA3-004/87-VOL-1] p 147 N88-17689
EYMAR, PATRICK
Logistics flow for Columbus MTFF
[IAF PAPER 87-39] p 123 A88-15829
Interim Flight Opportunity (IFO)
[IAF PAPER 87-379] p 138 A88-16054
Aerospatiale studies for IOC and AOC p 141 A88-21562

F

FABRICANT, DANIEL G.
Design, analysis, fabrication and test of the LAMAR protoflight mirror assembly p 10 A88-12719
FACIUS, R.
Radiation problems in manned space flight with a view to the Space Station p 132 N88-19934
FAGET, MAXIME A.
The Industrial Space Facility
[IAF PAPER 87-01] p 1 A88-15801
FALANGAS, ERIC T.
Momentum management and attitude control design for a Space Station p 55 A88-29253
FALKENHAYN, EDWARD
Multimission Modular Spacecraft (MMS): A serviceable design spacecraft p 6 N88-19501
FANG, LU YOU
Application of perturbation techniques to flexible multibody system dynamics p 14 A88-20908
FANG, XIAOWEN
Optimal control of large space structures via generalized inverse matrix
[NASA-CR-182336] p 59 N88-13907
FANSON, J. L.
Experimental studies of active members in control of large space structures
[AIAA PAPER 88-2207] p 56 A88-32178
FATEMI, NAVID
A novel photovoltaic power system which uses a large area concentrator mirror p 65 A88-11911
FAUCHERRE, M.
A test-bed for space interferometry: Space Platform Interferometer (SPI) p 5 N88-10640
FAYBISH, KARL A.
LERC power system autonomy program 1990 demonstration p 67 A88-11861
A systems engineering approach to automated failure cause diagnosis in space power systems p 68 A88-11870
FEE, D. C.
Monolithic fuel cell based power source for burst power generation p 71 A88-22681
FEMSE, W.
Simulation tools for the development of an autonomous rendezvous and docking system p 47 A88-13572
Control techniques for rendez-vous and docking p 51 A88-16311
Analysis of RVD operations in manned space missions p 61 N88-19494
Motion simulation for in-orbit operations p 62 N88-19514
EPOS: European Proximity Operations Simulation p 147 N88-19515
Rendezvous and docking (RVD) verification and demonstration in-orbit p 62 N88-19531
FERLET, ROGER
SPOT 1 - Earth observing satellite p 3 A88-26166
FERNANDEZ, K.
Development of a coupled expert system for the spacecraft attitude control problem p 61 N88-17223
FERNANDEZ, KEN
The use of computer graphic simulation in the development of on-orbit tele-robotic systems p 85 A88-21646
FERNS, D. C.
On-orbit servicing and cost effectiveness of Columbus polar platform concepts
[IAF PAPER 87-42] p 123 A88-15831
Commercial perspective of an imaging spectrometer development program p 165 N88-12138
FERRARESI, VALTAIR A.
Simulation and tests of a satellite attitude and orbit control system: General considerations concerning an example case (INPE) and design of a servo rate table
[INPE-4252-PRE/1154] p 62 N88-19572
FERRI, A. A.
Investigation of damping from nonlinear sleeve joints of large space structures p 56 A88-21596
FESTER, DALE A.
Tethers on stations and platforms
[AIAA PAPER 88-0534] p 113 A88-22399
FEUERBACHER, B.
Microgravity research and user support in the Space Station era - The Microgravity User Support Center
[IAF PAPER 87-390] p 110 A88-16061
FINDEN, L. E.
Space station resistojet system requirements and interface definition study
[NASA-CR-180832] p 80 N88-12541
FINN, TERENCE T.
Space station: Leadership for the future
[NASA-PAM-509/8-87] p 165 N88-10072
FINZI, A. E.
EURECA - An expert system for the management of experiments to be performed on a free-flying platform
[IAF PAPER 87-29] p 135 A88-15821
FIOCCHI, G.
Feasibility study of a stabilizer fin for the tethered satellite system p 111 A88-16860
FISCHER, JAMES R.
Report from the MPP Working Group to the NASA Associate Administrator for Space Science and Applications
[NASA-TM-87819] p 100 N88-11402
FISCHER, M.
Aspects and possibilities of an integrated energy and media supply system on H2/O2-base for manned space stations in the low earth orbit
[IAF PAPER 87-241] p 38 A88-15963
FITZ-COY, N. G.
An investigation of the damping phenomena in wire rope isolators p 21 A88-31597
FITZGERALD, STEVE M.
Aeroassisted orbital transfer vehicle guidance performance in the presence of density dispersions
[AIAA PAPER 88-0302] p 150 A88-22217
FITZPATRICK, TIMOTHY W.
Treatment bed microbiological control
[SAE PAPER 871492] p 42 A88-21148
FLEISCHMAN, G. L.
Advanced radiator concepts utilizing honeycomb panel heat pipes
[NASA-CR-172017] p 37 N88-12747

FLEMING, M. L.
Space Station body mounted radiator design
[SAE PAPER 871507] p 35 A88-21153
FLEMING, MIKE
Radiator selection for Space Station Solar Dynamic Power Systems p 32 A88-11806
FLETCHER, J. C.
Reusable space systems (Eugen Saenger Lecture, 1987) p 125 A88-32476
FLETCHER, L. S.
Thermal contact conductance in the presence of thin metal foils
[AIAA PAPER 88-0468] p 35 A88-22342
FLEURY, AGENOR DET.
Simulation and tests of a satellite attitude and orbit control system. General considerations concerning an example case (INPE) and design of a servo rate table
[INPE-4282-PRE/1154] p 62 N88-19572
FLEURY, AGENOR T.
Construction aspects of testbeds for attitude control systems simulation of artificial satellites
[INPE-4283-PRE/1155] p 61 N88-18616
FLOOD, DENNIS J.
Space solar cell research - Problems and potential p 70 A88-21605
FOELSCHE, G. A.
Transient response of joint dominated space structures - A new linearization technique
[AIAA PAPER 88-2393] p 24 A88-32325
FOLEY, THERESA M.
U.S. Space Platform firms aim for 1991 service start p 164 A88-27954
FOLKMAN, STEVEN L.
Measurement and modeling of joint damping in space structures
[AIAA PAPER 88-2449] p 17 A88-31378
FORD, DONNIE R.
Cooperating expert systems for power systems p 68 A88-11681
FORTINI, A.
Slosh dynamics in a toroidal tank p 78 A88-27888
FORTUNATO, FRED A.
Static feed electrolyzer technology advancement for space application
[SAE PAPER 871450] p 40 A88-21110
FORTUNATO, RONALD C.
The NORSTAR Program: Space shuttle to space station p 167 N88-17710
FOSSATI, D.
Fault tolerant onboard implementation of control procedures in tethered satellite p 110 A88-16285
FOTH, W. P.
Design and development of the life support subsystem of a laboratory model of the Botany Facility
[SAE PAPER 871519] p 43 A88-21164
FOUSHEE, H. CLAYTON
Crew productivity issues in long-duration space flight
[AIAA PAPER 88-0444] p 154 A88-22330
FOX, ALLEN
Binary mercury/organic Rankine cycle power systems p 63 A88-11795
FOX, BARRY R.
Planning and scheduling for robotic assembly p 90 N88-16416
FRANCOIS, H. G.
Man Tended Free Flyer configurations and servicing scenarios
[MBB-UR-E-984-87] p 125 A88-23990
FRANKLIN, I. V.
Large flexible solar arrays p 11 A88-15277
FREEMAN, KENNETH A.
Comparative study of cable construction for 20 kHz power distribution p 66 A88-11831
A concept for standard load center automation p 67 A88-11857
FREEMAN, MARSHA
Two days to Mars with fusion propulsion p 78 A88-29236
FREEMAN, MICHAEL S.
Third Conference on Artificial Intelligence for Space Applications, part 1
[NASA-CP-2492-Pt-1] p 89 N88-16360
FRENCH, R. L.
Space telerobotics technology demonstration program
[AAS PAPER 87-045] p 84 A88-17000
The NASA telerobot technology demonstrator p 85 A88-21651
FREUND, FRIEDEMANN
Physics and chemistry p 118 N88-15358
FREUND, M.
Physics and chemistry p 118 N88-15358
FRIEBELE, E. J.
Optical fiber waveguides for spacecraft applications p 95 A88-21618
FREDERICK, H.
Columbus preparatory program. Payload element study on a technology demonstration mission, executive summary
[CS-RP-AI-016] p 145 N88-10080
FREDLAND, PETER
Building intelligent systems - Artificial intelligence research at NASA Ames Research Center p 82 A88-15300
FRIEDRICH, H.
MTFF operational design features p 134 A88-15296
Man Tended Free Flyer configurations and servicing scenarios
[MBB-UR-E-984-87] p 125 A88-23990
Man-Tended Free Flyer operational design features p 126 N88-19485
FRISK, U. O.
Report on the scientific satellites of the European Space Agency
[ESA-SP-1090] p 116 N88-10081
FRITZSCHE, A.
Collector and receiver designs for high temperature Brayton cycle for space application
[IAF PAPER 87-228] p 69 A88-15953
FROMM, J.
A data base approach towards Columbus payload accomodation p 99 A88-21257
FRUSHON, CARL J.
Large space systems environmental entanglements
[AIAA PAPER 88-0388] p 14 A88-22286
FUELLEKRUG, U.
Survey of parameter estimation methods in experimental modal analysis p 24 A88-32718
FUENTES, M.
Robotics servicing experiment p 93 N88-19529
FUJII, HIRONORI
Mission function control applied to slew maneuver
[IAF PAPER 87-354] p 49 A88-16044
FUJIMORI, H.
Environmental control and life support system for Japanese Experiment Module
[SAE PAPER 871429] p 39 A88-21092
FUJIMORI, Y.
Modal damping measurement of MOS-1 Solar Array Paddle p 13 A88-16292
FULIGNI, FRANCO
Recent developments in gravity gradiometry from the Space-Shuttle-borne tethered satellite system p 112 A88-21531
FULWIDER, RICHARD, II
Implementation of expert system technology on the Space Station p 99 A88-21654
FUNTOVA, I. I.
Ballistocardiography in weightlessness research p 46 N88-19080
FURNISS, TIM
Mir - Soviet base in space p 129 A88-16378
FURUNE, H.
Sunlight supply and gas exchange systems in microalgal bioreactor p 44 N88-12258
FURUYA, AKIRA
Scanning laser radar system for rendezvous and docking in space
[IAF PAPER 87-53] p 48 A88-15838
FUSCO, G.
Analytical interactive approach for phenomena involving structures, thermal and control aspects. Volume 1: Theory
[ESA-CR(P)-2503-VOL-1] p 60 N88-16803
Analytical interactive approach for phenomena involving structures, thermal, and control aspects. Volume 2: Toward the solution
[ESA-CR(P)-2503-VOL-2] p 60 N88-16804
Analytical interactive approach for phenomena involving structures, thermal, and control aspects. Volume 3: Executive summary
[ESA-CR(P)-2503-VOL-3] p 60 N88-16805

G

GANSVIND, I. N.
The passive attitude motion of the orbital stations Salyut-6 and Salyut-7
[IAF PAPER 87-355] p 49 A88-16045
GAO, WEIBING
On local state feedback and stability domain estimation of nonlinear large scale systems p 144 A88-29245
GARBA, J. A.
Experimental studies of active members in control of large space structures
[AIAA PAPER 88-2207] p 56 A88-32178
GARCIA, RAFAEL
Test results of a shower water recovery system
[SAE PAPER 871512] p 42 A88-21158
GARN, P. A.
Analysis of a rotating advanced-technology space station for the year 2025
[NASA-CR-178345] p 107 N88-19580
GARRETT, L. BERNARD
Design and assembly sequence analysis of option 3 for CETF reference space station
[NASA-TM-100503] p 126 N88-13369
GARTRELL, CHARLES F.
Spacecraft technology trends - A view from the past
[IAF PAPER 87-07] p 161 A88-15807
In-space research, technology and engineering experiments and Space Station p 3 A88-27750
GARVIN, M.
Exobiology and botany facilities for EURECA p 148 N88-19898
GASSET, G.
Antibiotic activity in space, results and hypothesis p 159 N88-19952
GATEWOOD, GEORGE D.
Performance considerations for the astrometric telescope facility on the phase 1 space station
[NASA-TM-100040] p 45 N88-14898
GATSONIS, N. A.
A simple model for the initial phase of a water plasma cloud about a large structure in space
[AIAA PAPER 88-0430] p 95 A88-22320
Plasma contactors for use with electrodynamic tethers for power generation
[NASA-CR-182424] p 73 N88-16547
GAUDET, JOHN A.
Large space systems environmental entanglements
[AIAA PAPER 88-0388] p 14 A88-22286
GAULT, DONALD
Planetary science p 5 N88-15356
GAUSE, RAYMOND L.
Assessment of external contamination for Space Station scientific payloads
[SAE PAPER 871476] p 130 A88-21131
GAVIN, R. T.
Development of a cooperative operational rendezvous plan for Eureca and other maneuvering Shuttle payloads
[IAF PAPER 87-218] p 123 A88-15948
GAZENKO, O. G.
Man in space flight
[IAF PAPER 87-527] p 152 A88-16150
Medlab: A project of a medical laboratory in space p 159 N88-19946
GAZENKO, OLEG GEORGIEVICH
Mankind and space p 164 A88-29410
GAZEY, S.
The Columbus space segment
[IAF PAPER 87-66] p 136 A88-15845
GAZEY, SAMI
Columbus Space Segment definition p 133 A88-15293
GEER, CHARLES W.
NASA-STD-3000, Man System Integration Standards - The new space human engineering standards
[IAF PAPER 87-550] p 152 A88-16167
GEHLING, R. N.
Large space structure damping treatment performance - Analytic and test results p 20 A88-31586
GEISLER, WLADYSLAW
Educational and pedagogical importance of astronautics
[IAF PAPER 87-520] p 162 A88-16148
GEOFFROY, AMY L.
Power and resource management scheduling for scientific space platform applications p 108 A88-11880
GERHOLD, C. H.
Active vibration control in microgravity environment p 55 A88-31565
GERHOLD, CARL H.
Active control of flexural vibrations in beams p 59 N88-14866
GERVIN, JANETTE C.
Space Station accommodation of attached payloads
[IAF PAPER 87-97] p 103 A88-15868
GESING, W.
Decentralized control of third generation spacecraft p 15 A88-27356
GETZSCHMANN, A.
Rendezvous and docking verification and demonstration in orbit, executive summary
[MBB-309-16/86] p 61 N88-17719
Rendezvous and docking (RVD) verification and demonstration in-orbit p 62 N88-19531
GHOLDSTON, EDWARD W.
Use of a distributed microprocessor network for control of the Space Station electrical power system p 67 A88-11856

GIAMPALMO, GIUSEPPE
Trades and problems in the definition of the Columbus operation concept
[IAF PAPER 87-83] p 136 A88-15857
GIANI, F.
Electrical current flow across the TSS - The core equipment and other related technical issues
[IAF PAPER 87-252] p 109 A88-15871
Columbus preparatory program. Payload element study on a technology demonstration mission, executive summary
[CS-RP-AI-016] p 145 N88-10080
GIANNINI, G.
Fault tolerant onboard implementation of control procedures in tethered satellite p 110 A88-16295
GIBBINS, M. N.
Space station integrated wall design and penetration damage control
[NASA-CR-179169] p 25 N88-10070
GIBBINS, MARTIN N.
Hypervelocity impact damage assessment for Space Station
[AIAA PAPER 88-2485] p 18 A88-31388
Space Station pressure wall repair techniques
[AIAA PAPER 88-2488] p 19 A88-31397
GILL, ESTHER NAOMI
The feasibility of using TAE as the UIL for the space station and for other internal NASA tasks and projects p 9 N88-15618
GINGERICH, M. E.
Optical fiber waveguides for spacecraft applications p 95 A88-21618
GIUNTINI, R. E.
A model for enveloping Space Station logistics requirements p 102 A88-15286
GLASGOW, THOMAS
Research opportunities in microgravity science and applications during Shuttle hiatus p 108 A88-13164
GLASSMAN, TERRY
Space station group activities habitability module study. A synopsis p 6 N88-19886
GLATMAN, L. I.
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment p 145 N88-12917
GLOWCZWSKI, R. V.
Space Station supply, product return, and trash disposal
[IAF PAPER 87-219] p 123 A88-15949
GOEBEL, JOHN
Astrophysics and the solar nebula p 118 N88-15355
GOELZ, G.
A data base approach towards Columbus payload accomodation p 99 A88-21257
GOHRING, JOHN
Power and resource management scheduling for scientific space platform applications p 108 A88-11860
GOLDSTEIN, STANLEY H.
National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 1
[NASA-CR-172009-VOL-1] p 166 N88-14855
National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 2
[NASA-CR-172009-VOL-2] p 166 N88-14874
GOO, STEVE D.
Pumped two-phase ammonia thermal bus test bed
[SAE PAPER 871442] p 34 A88-21104
GOODMAN, JINDRA
Atmospheric science p 5 N88-15357
GORDON, WILLIAM L.
Degradation mechanisms of materials for large space systems in low Earth orbit
[NASA-CR-181472] p 96 N88-10896
GORENSTEIN, PAUL
Design, analysis, fabrication and test of the LAMAR protoflight mirror assembly p 10 A88-12719
GORET, PHILIPPE
A telescope for high energy gamma-ray measurements in the Space Station era
[AIAA PAPER 88-0652] p 114 A88-22485
GOROVE, STEPHEN
The applicable legal regime for international cooperation on space stations p 133 A88-13448
GOSSAIN, DEV M.
The Canadian Mobile Servicing System for Space Station servicing p 82 A88-15289
GOTO, NORIHIRO
Root locus method for active control of flexible systems p 53 A88-24506
GOTTLIEB, DAVID
Computational methods for problems in aerodynamics and large space structure using parallel and vector architectures
[AD-A185401] p 27 N88-13294
GRAF, GARY
Off to see the wizard p 164 A88-22957
GRAF, JOCHEN
Trades and problems in the definition of the Columbus operation concept
[IAF PAPER 87-83] p 136 A88-15857
GRANDHI, R. V.
Optimum design of structures with multiple constraints p 16 A88-28042
GRARD, R.
Report on the scientific satellites of the European Space Agency
[ESA-SP-1090] p 116 N88-10081
GRAUL, S.
Automatic in-orbit payload deployment mechanisms, logistic operations and transport vehicle design compatibilities p 92 N88-19493
GRAY, P. F.
SAFIRE - A novel high resolution cooled spectrometer for atmospheric research
[IAF PAPER 87-137] p 109 A88-15894
GRECHKO, G. M.
Reconstruction of the vertical atmospheric temperature profile on the basis of refraction measurements from the Salyut-7 orbital station p 131 A88-23930
GREELEY, RONALD
Planetary science p 5 N88-15356
GREEN, BYRON DAVID
Shuttle experiments to measure the optical environments surrounding large space structures
[AIAA PAPER 88-0432] p 14 A88-22321
GREENBERG, J. MAYO
Astrophysics and the solar nebula p 118 N88-15355
GREENBERG, JOEL S.
The economics of satellite retrieval
[AIAA PAPER 88-0843] p 164 A88-27584
GREENE, MICHAEL
Robustness of active modal damping of large flexible structures p 11 A88-13929
GREENLEE, W. J.
Binary mercury/organic Rankine cycle power systems p 63 A88-11795
GREENWAY, W. I.
Spacecraft solar array substrate development p 68 A88-13187
GREGG, HUGH
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems
[NASA-TM-89705] p 88 N88-15497
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems p 89 N88-16373
GREGORY, JOHN C.
A measurement of the angular distribution of 5 eV atomic oxygen scattered off a solid surface in earth orbit p 130 A88-16866
GREY, JERRY
Space Station careens past all obstacles p 159 A88-10367
GRIANIK, MIKHAIL VASIL'EVICH
Deployable umbrella reflector antennas p 143 A88-27743
GRIFFIN, J. H.
Transient response of joint dominated space structures - A new linearization technique
[AIAA PAPER 88-2393] p 24 A88-32325
GRIFFIN, THOMAS J.
The GSFC Flight Support System for on-orbit satellite servicing
[AIAA PAPER 88-0448] p 124 A88-22334
GRIFFITHS, H. D.
Swath altimetry of oceans and terrain p 115 A88-27838
GRIGOR'EV, A. I.
Man in space flight
[IAF PAPER 87-527] p 162 A88-16150
Biomedical payload of the French-Soviet long duration flight
[IAF PAPER 87-541] p 152 A88-16159
GRIGORIEV, A. I.
Medlab: A project of a medical laboratory in space p 159 N88-19946
GRIMARD, M.
Evolution towards an autonomous European manned space infrastructure
[IAF PAPER 87-67] p 136 A88-15846
GRIMBERT, D.
Rendezvous and docking verification and demonstration in orbit, executive summary
[MBB-303-16/86] p 61 N88-17719
Dynamic testing of a docking system p 62 N88-19516
GROEPPER, P.
Space Station logistic support by Aries
[IAF PAPER 87-222] p 137 A88-15950
GRONET, MARC J.
Space Station - A focus for the development of structural dynamics scale model technology for large flexible space structures
[AIAA PAPER 88-2483] p 19 A88-31392
GROSCH, CHESTER
Report from the MPP Working Group to the NASA Associate Administrator for Space Science and Applications
[NASA-TM-87819] p 100 N88-11402
GROSS, ALAN E.
Remote repair demonstration of Solar Maximum main electronics box p 128 N88-19510
GROUNDS, PHYLLIS
Biotechnology opportunities on Space Station
[SAE PAPER 871468] p 154 A88-21124
GRUEN, RAINER
Future European ground segment p 133 A88-15279
Future European ground segment
[MBB-UR-E-976-87] p 142 A88-23969
GUELL, A.
Cosmonaut behaviour in orbital flight situation - Preliminary ethological analysis
[IAF PAPER 87-529] p 152 A88-16151
GUEST, S.
An investigation of the damping phenomena in wire rope isolators p 21 A88-31587
GUEST, S. H.
Experimental study of damping of graphite epoxy composite material of the Space Telescope truss system p 56 A88-31605
GUIDONI, U.
Research on Electrodynamic Tether Effects (RETE) experiment Electrical Ground Support Equipment (EGSE)
[IFSI-87-2] p 100 N88-13378
RETE experiment Assembly, Integration, and Verification (AIV) activities
[IFSI-87-6] p 117 N88-13380
GULINO, DANIEL A.
Oxidation-resistant reflective surfaces for solar dynamic power generation in near earth orbit p 70 A88-18523
GULLAHORN, GORDON E.
Recent developments in gravity gradiometry from the Space-Shuttle-borne tethered satellite system p 112 A88-21531
GUNDEL, A.
Implications of shiftwork in space for human physiology experiments p 129 N88-19942
GUROVSKII, N. N.
Results of medical investigations conducted aboard the 'Salyut-6'-'Soyuz' orbital research complex p 135 A88-15650
GURVICH, A. S.
Reconstruction of the vertical atmospheric temperature profile on the basis of refraction measurements from the Salyut-7 orbital station p 131 A88-23930
GUSTAFSON, ERIC
Heat pipe radiators for solar dynamic space power system heat rejection p 33 A88-11807
Design of an ammonia two-phase Prototype Thermal Bus for Space Station
[SAE PAPER 871506] p 35 A88-21152
High thermal-transport capacity heat pipes for space radiators
[SAE PAPER 871509] p 35 A88-21155
GUYENNE, DUC
ESA Bulletin No. 25
[ISSN-0376-4265] p 146 N88-16767
GUYENNE, T. D.
Commercial Opportunities for Remote Sensing with Polar Platforms
[ESA-SP-269] p 117 N88-12131
GUYENNE, T. DUC
Proceedings of the ESA Workshop on Co-Orbiting Platform Elements (COPE)
[ESA-SP-1093] p 148 N88-16777

H

HACK, EDMUND
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems
[NASA-TM-89705] p 88 N88-15497
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems p 89 N88-16373
HACK, EDMUND C.
TDAS: The Thermal Expert System (TEXSYS) data acquisition system p 102 N88-17258

HACKLER, IRENE M.
Incipient fault detection and power system protection for spaceborne systems p 86 A88-11826
HADDOCK, REX
Stress rupture behavior of carbon-fiber metal-lined pressure vessels for 30-year operation in space
[AIAA PAPER 88-2479] p 19 A88-31391
HAFF, P.
Physics and chemistry p 118 N88-15359
HAFTKA, RAPHAEL T.
Spillover stabilization of large space structures
[AIAA PAPER 88-2464] p 55 A88-31390
HAGAMAN, JANE A.
Space Construction
[NASA-CP-2490] p 26 N88-10870
HAGER, R. W.
Selected advanced technology studies for the U.S. Space Station
[IAF PAPER 87-79] p 2 A88-15854
HAIDER, O.
Stress and deformation analysis and tests of composite structures for space application
[IAF PAPER 87-312] p 12 A88-16011
HAINES, RICHARD F.
Space vehicle approach velocity judgments under simulated visual space conditions
[NASA-TM-89437] p 158 N88-19094
HAISLER, W. E.
Finite-element model for the thermoelastic analysis of large composite space structures p 14 A88-18632
HALL, ARNOLD M.
Parametrics of nickel-hydrogen cell design
p 75 A88-11912
HALL, D. W.
Carbon Dioxide observational platform system (CO-OPS) Feasibility Study
[NASA-CR-179225] p 118 N88-14113
Feasibility study of a carbon dioxide observational platform system. Volume 2: Programmatics
[NASA-CR-180404] p 118 N88-14114
HALL, DANA L.
Space Station Information System - Concepts and international issues
[IAF PAPER 87-76] p 98 A88-15851
HALL, J. B., JR.
Hybrid honeycomb panel heat rejection system
[SAE PAPER 871419] p 34 A88-21083
HALL, JOHN B., JR.
Environmental control and life support systems analysis for a Space Station life sciences animal experiment
[SAE PAPER 871417] p 39 A88-21081
Design and assembly sequence analysis of option 3 for CETF reference space station
[NASA-TM-100503] p 126 N88-13369
HALL, REX
The Soviet cosmonaut team, 1978-1987
p 144 A88-30185
HALL, STEVEN B.
The distributed AI system for the dynamic allocation and management of power (DAISY-DAMP) testbed
p 84 A88-21638
HALL, STEVEN R.
Active modification of wave reflection and transmission in flexible structures p 16 A88-27395
HAM, F. M.
Development of the Maui Flight System linear dc motor inertial actuator
[AAS PAPER 87-021] p 13 A88-16990
HAMELIN, M.
Laboratory simulation of the electrodynamic interactions of a tethered satellite with an ionospheric plasma
[IFSI-88-3] p 119 N88-15822
HAMESFAHR, A.
Study of a payload for Columbus Polar Platform Earth observation demonstration mission, executive summary
[ESA-CR(P)-2412] p 116 N88-10079
HAMILL, PATRICK
Atmospheric science p 5 N88-15357
HAMILTON, BRIAN J.
Pointing mount with active vibration isolation for large payloads
[AAS PAPER 87-033] p 103 A88-16993
HAMSATH, N.
The dynamics and control of large space structures after the onset of thermal shock
[IAF PAPER 87-351] p 49 A88-16041
HANABUSA, O.
An experimental study of the Bosch and the Sabatier CO2 reduction processes
[SAE PAPER 871517] p 43 A88-21162
HANJE, J.
Study of fault tolerant techniques for satellite data handling
[FTT/REP/0001/SAAB] p 101 N88-13880
HANKS, BRANTLEY R.
Structures and Materials Working Group report
p 25 N88-10093
HANSEN, E.
Lowering the costs of satellite operations - Lessons learned from the Solar Mesosphere Explorer (SME) mission
[AIAA PAPER 88-0549] p 7 A88-22412
HANSEN, IRVING G.
EMC and power quality standards for 20-kHz power distribution p 66 A88-11830
Status of 20 kHz space station power distribution technology
[NASA-TM-100781] p 73 N88-15838
HARA, NORIKAZU
Conceptual design of the advanced technology platform
[IAF PAPER 87-02] p 108 A88-15802
HARDER, G.
Identification and control of flexible structures
p 54 A88-27768
HARMON, PHILLIP E.
Design and development of a computer-assisted ground control technique for Space Station robotics
p 82 A88-15284
HARRAND, V.
Solid modeling for the manipulative robot arm (power) and adaptive vision control for space station missions
p 89 N88-16409
HARRIES, J. E.
SAFIRE - A novel high resolution cooled spectrometer for atmospheric research
[IAF PAPER 87-137] p 109 A88-15894
HARRIS, J. MILTON
Use of hydrophilic polymer coatings for control of electroosmosis and protein adsorption
p 119 N88-15620
HARRIS, LEONARD A.
Technology - The basis for the past, the key to the future
[IAF PAPER 87-47] p 161 A88-15833
Comments on the 'early experimental validation' session of the Second International Conference on Tethers in Space
[AIAA PAPER 88-0535] p 113 A88-22400
HARRISON, F. WALLACE, JR.
System architecture for telerobotic servicing and assembly tasks p 85 A88-21649
HARRISON, JAMES K.
Tethers in space - A broad perspective
[AIAA PAPER 88-0530] p 113 A88-22396
HARRISON, M. H.
Has manned space flight a future?
p 159 A88-10850
HARTLEY, JAMES G.
Development of an emulation-simulation thermal control model for space station application
[NASA-CR-182409] p 37 N88-15823
HARWELL, MORRIS C.
Space station operating system study
[NASA-CR-179308] p 127 N88-18619
HASKELL, G. P.
Space station overview p 167 N88-16780
Use of Space Station for space science
p 120 N88-16782
HASLETT, ROBERT
Thermal Control Working Group report
p 36 N88-10094
HASTINGS, D. E.
Plasma contactors for use with electrodynamic tethers for power generation
[IAF PAPER 87-251] p 69 A88-15970
A simple model for the initial phase of a water plasma cloud about a large structure in space
[AIAA PAPER 88-0430] p 95 A88-22320
Plasma contactors for use with electodynamic tethers for power generation
[NASA-CR-182424] p 73 N88-16547
HATANO, S.
Experimental study for carbon dioxide removal system in Space Station
[SAE PAPER 871516] p 43 A88-21161
HATHAWAY, R.
On-orbit servicing and cost effectiveness of Columbus polar platform concepts
[IAF PAPER 87-42] p 123 A88-15831
HATSUDA, TAKESHI
Geostationary tether satellite system and its application to communications systems p 115 A88-28974
HATTORI, A.
Environmental control and life support system for Japanese Experiment Module
[SAE PAPER 871429] p 39 A88-21092
HAVENS, KATHRYN A.
A synopsis of the EVA training conducted on EASE/ACCESS for STS-61-B p 126 N88-10879
HAVENS, V. N.
Toluene stability Space Station Rankine power system
p 63 A88-11794
Solar dynamic organic Rankine cycle heat rejection system simulation p 65 A88-11808
HAWKINS, GERALD W.
Marshall Space Flight Center's role in EASE/ACCESS mission management p 27 N88-10875
HAYDUK, ROBERT J.
Large space structures - Structural concepts and materials
[SAE PAPER 872429] p 17 A88-30999
HAYNES, WILLIAM E.
On-orbit servicing enhancements with Crewlock EVA operations from the Spacehab module
[SAE PAPER 871496] p 124 A88-21148
HE, XIANGWEI
Feedback control for attitude control system of the elastic vehicle p 48 A88-14596
HE, XIAOHUA
Kinetic isolation tether experiment
[NASA-CR-182458] p 120 N88-16810
HEALEY, K. J.
NASA Systems Autonomy Demonstration Program - A step toward Space Station automation
p 64 A88-21639
HEALEY, KATHLEEN
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems
[NASA-TM-89705] p 66 N88-15497
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems
p 89 N88-16373
HEALEY, KATHLEEN J.
TDAS: The Thermal Expert System (TEXSYS) data acquisition system p 102 N88-17258
HEARD, WALTER L., JR.
Astronaut/EVA construction of Space Station
[AIAA PAPER 88-2459] p 125 A88-31382
Results of the ACCESS experiment
p 27 N88-10880
HECHLER, F.
Safe and fuel minimum reference trajectories for closed loop controlled approaches p 61 N88-19488
HECK, M.
Steady state micro-g environment on Space Station
[AIAA PAPER 88-2462] p 4 A88-31385
The impact of asymmetric physical properties on large space structures
[AIAA PAPER 88-2486] p 19 A88-31395
Orbit lifetime characteristics for Space Station
[AIAA PAPER 88-2490] p 55 A88-31399
HECK, MICHAEL L.
Space Station attitude control momentum requirements
[AIAA PAPER 88-0672] p 51 A88-22502
HECKER, FRANK
Proceedings of the Fourth Annual LS Space Development Conference p 163 A88-22000
HEER, EWALD
Progress towards autonomous, intelligent systems
[IAF PAPER 87-31] p 83 A88-15823
HEFTMAN, K.
Principles of operations cooperation between the United States and Europe p 141 A88-21564
HEIDENREICH, GARY
Integrated heat pipe-thermal storage system performance evaluation p 32 A88-11803
HEIDMANN, H. J.
The DFS platform and its applications
[IAF PAPER 87-470] p 138 A88-16119
HEIMBOLD, G.
EPOS - A facility for simulating operations near spacecraft p 56 A88-32145
EPOS: European Proximity Operations Simulation
p 147 N88-19515
HEJTMANCIK, KELLY E.
A solid phase enzyme-linked immunosorbent assay for the antigenic detection of Legionella pneumophila (serogroup 1): A compliment for the space station diagnostic capability p 157 N88-14868
HELMREICH, ROBERT L.
The role of psychologists in future spaceflight
p 159 A88-10958
HELWIG, G.
Collector and receiver designs for high temperature Brayton cycle for space application
[IAF PAPER 87-226] p 69 A88-15953
HEMMERLING, DAVID
Stress rupture behavior of carbon-fiber metal-lined pressure vessels for 30-year operation in space
[AIAA PAPER 88-2479] p 19 A88-31391
HENDERSON, KEITH
Biotechnology opportunities on Space Station
[SAE PAPER 871468] p 154 A88-21124

HENDRICKS, CARL L.
Protective coatings for composite tubes in space applications p 94 A88-13239
HENDRICKS, SCOTT L.
Damage detection and location in large space trusses [AIAA PAPER 88-2461] p 18 A88-31384
HENLEY, MARK
The space based OTV and the establishment of the next launch site [IAF PAPER 87-196] p 149 A88-15833
HERBER, NIKOLAUS
EVA for a European Scenario [SAE PAPER 871432] p 123 A88-21095
HERMAN, DANIEL H.
The impact of launch vehicle constraints on U.S. Space Station design and operations [IAF PAPER 87-72] p 2 A88-15846
HERRIN, MARK T.
Preliminary design of the Space Station internal thermal control system [SAE PAPER 871505] p 35 A88-21151
HERRMANN, FREDERICK T.
Advanced protein crystal growth flight hardware for the Space Station [AIAA PAPER 88-0345] p 3 A88-22253
HERTZBERG, A.
Ram accelerator direct launch system for space cargo [IAF PAPER 87-211] p 162 A88-15944
HEUSER, JAN
Space Station ground data management system p 98 A88-15262
HEYMAN, JOSEPH S.
An amplitude modulated laser system for distance and displacement measurement p 47 A88-12813
HEYN, J.
European EVA requirements and space suit design [IAF PAPER 87-41] p 152 A88-15830
HEYWARD, ANN O.
An allotment planning concept and related computer software for planning the fixed satellite service at the 1988 space WARC [NASA-TM-100244] p 165 N88-11944
HIERONIMUS, ANNE-MARIE
Possible commercial use of the polar platforms p 165 N88-12132
HIGGINBOTHAM, JOHN B.
Review of commercial spacecraft: Recovery and repair experiences. Implications for future spacecraft designs and operations p 128 N88-19528
HILL, ROBERT
Mission Peculiar Equipment Support Structure: A platform for space construction p 26 N88-10874
HILZENBECHER, U.
Robotic sensors and actuators for a service manipulator system. Volume 1: Executive summary [MATRA-EPT/DT/VT187/120] p 87 N88-10341
Robotic sensors and actuators for a service manipulator system. Volume 2: Service Manipulator System (SMS) handbook [MATRA-EPT/DT/VT187/227] p 87 N88-10342
Robotic sensors and actuators for a service manipulator system. Volume 3, phase A report and program plan [MATRA-EPT/DT/VT187/228] p 87 N88-10343
HINKAL, SANFORD W.
The Flight Telerobotic Servicer (FTS) - A focus for automation and robotics on the Space Station [IAF PAPER 87-25] p 62 A88-15817
HINMAN, ELAINE
The use of computer graphic simulation in the development of on-orbit tele-robotic systems p 85 A88-21646
HIRZINGER, G.
Man tended free flyer interior equipment for manned and automated operation [IAF PAPER 87-75] p 136 A88-15850
HITCHENS, G. D.
Electrochemical processing of solid waste [NASA-CR-182413] p 157 N88-15852
HITE, GERALD E.
Power and charge dissipation from an electrodynamic tether p 73 N88-14869
HOCKNEY, RICHARD
Application of magnetic bearings to high-torque, satellite attitude control wheels p 47 A88-11908
HOEHN, FRANK
Radiator selection for Space Station Solar Dynamic Power Systems p 32 A88-11806
HOFFBAUER, M. A.
High intensity 5 eV O-atom exposure facility for material degradation studies p 96 N88-10847
HOFFMAN, R. W.
Degradation mechanisms of materials for large space systems in low Earth orbit [NASA-CR-181472] p 96 N88-10896
HOFFMAN, STEPHEN J.
Transitioning from Space Shuttle to Space Station on-orbit servicing p 121 A88-15290
HOKAMOTO, SHINJI
Root locus method for active control of flexible systems p 53 A88-24506
HOLBEN, WILFORD S., JR.
An amplitude modulated laser system for distance and displacement measurement p 47 A88-12813
HOLLARS, M. G.
Experiments in advanced control concepts for space robotics - An overview of the Stanford Aerospace Robotics Laboratory [AAS PAPER 87-044] p 83 A88-16899
HOLLAWAY, L.
A composite structural system for a large collapsible space antenna p 16 A88-31403
HOLLIER, P.
Study of a payload for Columbus Polar Platform Earth observation demonstration mission, executive summary [ESA-CR(P)-2412] p 116 N88-10079
HOLLOWAY, REGINALD M.
NASA spaceborne optical disk recorder development p 100 A88-29820
HOLLY, S.
Optical measurements pertaining to Space Station solar dynamic power systems [IAF PAPER 87-229] p 69 A88-15954
HOLMES, H. R.
Space erectable radiator system development [AIAA PAPER 88-0469] p 36 A88-22345
HOLMQUIST, G. R.
Spacecraft solar array substrate development p 68 A88-13187
HOMMA, MASANORI
Conceptual design of the advanced technology platform [IAF PAPER 87-02] p 108 A88-15802
HOOGSTRATEN, J.
EUROSIM: A design concept for an in-orbit operations simulator p 148 N88-19517
HOOVER, MARK D.
Space nuclear power systems 1986. Proceedings of the Third Symposium, Albuquerque, NM, Jan. 13-16, 1986 p 71 A88-22676
HORAN, STEPHEN
High data rate modem simulation for the space station multiple-access communications system p 101 N88-14870
HORN, ALBERT E.
Space station operating system study [NASA-CR-179308] p 127 N88-18619
HORN, F. L.
Particle bed reactor propulsion vehicle performance and characteristics as an orbital transfer rocket p 78 A88-22707
HORNECK, G.
European activities in exobiological research in space p 158 N88-19929
HORNER, G. C.
Dynamics and control of a planar truss actuator p 55 A88-31564
HORRIGAN, D. J.
Overview of crew member energy expenditure during Shuttle Flight 61-B EASE/ACCESS task performance p 156 N88-10882
HOSSAIN, S. A.
Distributed systems approach to the identification of flexible structures p 15 A88-22808
HOSSIAN, S. A.
System identification of flexible structures [AIAA PAPER 88-2361] p 23 A88-32301
HOTTES, KLAUS
Social factors in space station interiors p 46 N88-19888
HOUPIS, HARRY
Planetary science p 5 N88-15356
HOUSNER, J. M.
A finite element method for time varying geometry in multibody structures [AIAA PAPER 88-2234] p 21 A88-32197
HOUSNER, JERROLD M.
The nonlinear behavior of a passive zero-spring-rate suspension system [AIAA PAPER 88-2316] p 57 A88-32264
HOWLAND, T. P.
Use of communicating expert systems in fault diagnosis for Space Station applications p 43 A88-21635
HSIA, WEI-SHEN
Stochastic model of the NASA/MSFC ground facility for large space structures with uncertain parameters: The maximum entropy approach [NASA-CR-181489] p 27 N88-12343
HSIEH, B.-J.
Development of a coupled expert system for the spacecraft attitude control problem p 61 N88-17223
HU, A.
Convergence properties of modal costs for certain distributed parameter systems p 20 A88-31570
HUBER, WILLIAM G.
Orbital Maneuvering Vehicle - New capability [IAF PAPER 87-194] p 149 A88-15831
HUDSON, WAYNE R.
Spacecraft technology trends - A view from the past [IAF PAPER 87-07] p 161 A88-15807
HUGHES, ANGI
Prototype resupply scheduler p 9 N88-16429
HUUSER, R. H.
A preliminary study of a fluid science laboratory for space station (Columbus). Part 4: Executive summary [NLR-TR-87023-L-PT-4] p 79 N88-11072
HUMPHRIES, WILLIAM R.
Environmental control and life support testing at the Marshall Space Flight Center [SAE PAPER 871453] p 40 A88-21113
Technology demonstrator program for Space Station Environmental Control Life Support System [SAE PAPER 871456] p 41 A88-21115
HUNT, J. J.
Commercial Opportunities for Remote Sensing with Polar Platforms [ESA-SP-269] p 117 N88-12131
HUNTON, DON E.
High intensity 5 eV O-atom exposure facility for material degradation studies p 96 N88-10847
HURLBUT, F. C.
Tether satellite potential for rarefied gas aerodynamic research [AIAA PAPER 88-0687] p 114 A88-22513
HUSE, KARSTEN
Man Tended Free Flyer utilization aspects [MBB-UR-E-981-87] p 142 A88-23991
HUSTON, R. L.
Dynamics of large constrained flexible structures p 16 A88-29509
HYE, ABDUL
Space Station Active Thermal Control System modeling [AIAA PAPER 88-0473] p 36 A88-22349
HYLAND, DAVID C.
Maximum entropy/optimal projection design synthesis for decentralized control of large space structures [AD-A186359] p 29 N88-15003

I

ICHIDA, KAZUO
Two-dimensionally deployable 'SHOF' truss [IAF PAPER 87-319] p 12 A88-16017
ICHIKAWA, SHINICHIRO
An experimental study on flexible spacecraft three-axis attitude control p 53 A88-26356
IHRIE, D.
An AI approach for scheduling space-station payloads at Kennedy Space Center p 90 N88-16425
IIZUKA, I.
Automation and robotics technology application to JEM [IAF PAPER 87-74] p 136 A88-15849
IKAWA, HIDEO
Effect of rotating earth for analysis of aeroassisted orbital transfer vehicles p 3 A88-26257
ILYIN, E. A.
Mediab: A project of a medical laboratory in space p 159 N88-19946
ILYIN, V. K.
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment p 143 N88-12917
IMAI, RYOICHI
Conceptual design of the advanced technology platform [IAF PAPER 87-02] p 108 A88-15802
IMAKITA, A.
An initial study of remotely manipulated stud welding for space applications p 88 A88-31274
INADA, TADAHICO
Japan's contribution to the Space Station program p 142 A88-21574
INMAN, D. J.
Low authority threshold control for large flexible structures [AIAA PAPER 88-2270] p 22 A88-32226
INMAN, DANIEL J.
Optimal on-line measurement system configuration strategies [AIAA PAPER 88-2341] p 9 A88-32284
ISHIJIMA, SHINTARO
Mission function control applied to slew maneuver [IAF PAPER 87-354] p 49 A88-15044

235

ISHIZU, NOBUO
Development of on-board satellite communications equipment in the Geostationary Platform era
[IAF PAPER 87-495] p 110 A88-16136
ITO, T.
Development scenario of H-II Orbiting Plane, HOPE
[IAF PAPER 87-210] p 48 A88-15943
IWABURA, TATSUCHI
The feasibility of Chlorella as the exchanger of CO2 for O2 and the food resources in the Space Station
p 43 A88-29136
IWATA, TOSHIAKI
Development of a master slave manipulator system for space use p 86 A88-26975

J

JABLONSKI, A.
The Spacebus platforms
[AIAA PAPER 88-0775] p 115 A88-27535
JACKSON, JOHN K.
Initial results of integrated testing of a regenerative ECLSS at MSFC
[SAE PAPER 871454] p 41 A88-21114
JACKSON, ROBERT W.
An operations concept for the Space Station based Astrometric Telescope Facility
[AIAA PAPER 88-0447] p 113 A88-22233
JACOBS, S.
Space station contamination considerations
p 131 N88-10859
JAKOBSEN, P.
Report on the scientific satellites of the European Space Agency
[ESA-SP-1090] p 116 N88-10081
JAMAR, PAMELA G.
Impact of intelligent systems on Space Station man-machine interface (MMI) design p 85 A88-21655
JAMIN-CHANGEART, F.
Metallurgy laboratory for Columbus, executive summary
[SNIAS-813-CA/TS] p 145 N88-10980
JANAUER, GILBERT E.
Treatment bed microbiological control
[SAE PAPER 871492] p 42 A88-21148
JANIK, DANIEL S.
Medical effects of iodine disinfection products in spacecraft water
[SAE PAPER 871490] p 154 A88-21144
JANISZEWSKI, A. M.
Optimal reconfiguration of thermally distorted wire mesh reflectors for large space antennas
[AIAA PAPER 88-2340] p 22 A88-32293
JANSCHEK, K.
Decentralized/hierarchical control for large flexible spacecraft
[MBB-LR-967-87] p 52 A88-23982
JANSSEN, P.
Grel driven kinematic simulation of flexible arm robot for space station missions p 89 N88-16388
JAQUES, BOB
The incredibly versatile space tether
p 114 A88-24454
JASON, NORA H.
Spacecraft fire detection and extinguishment: A bibliography
[NASA-CR-180880] p 158 N88-18612
JEFFERIES, K. S.
Optical measurements pertaining to Space Station solar dynamic power systems
[IAF PAPER 87-229] p 60 A88-15954
JENKINS, LYLE M.
Telerobot for space station p 91 N88-17274
JENKS, C. S.
REPPRE-REPSIM-REPSTA - Programs for evaluating the availability and maintenance of space systems
p 125 A88-27778
JENNINGS, JERRY L.
OMV servicing missions from Space Station
p 121 A88-15291
JENNRICH, CARLETON E.
Remote repair demonstration of Solar Maximum main electronics box p 129 N88-19510
JOHNS, GORDON L.
From Space Shuttle to Space Station - Graduating from paper to electronic media
[AIAA PAPER 88-0442] p 163 A88-22328
JOHNSON, BRUCE
Application of magnetic bearings to high-torque, satellite attitude control wheels p 47 A88-11908
JOHNSON, C. C.
The Industrial Space Facility
[IAF PAPER 87-01] p 1 A88-15801
Water management requirements for animal and plant maintenance on the Space Station
[SAE PAPER 871469] p 41 A88-21125
JOHNSON, CATHERINE C.
OSSA Space Station waste inventory
[SAE PAPER 871413] p 39 A88-21078
JOHNSON, GARY S.
Potential for on-orbit manufacture of large space structures using the pultrusion process
[NASA-TM-4016] p 29 N88-13388
JOHNSON, JODIE V.
Monitoring of space station life support systems with miniature mass spectrometry and artificial intelligence
p 45 N88-16376
JOHNSON, NICHOLAS
1986 - Very good year for Soviets
p 138 A88-16379
JOHNSON, NICHOLAS L.
Artificial space debris p 130 A88-17944
JOHNSON, R. R.
Development and properties of aluminum-clad graphite/epoxy tubes for space structures
[AIAA PAPER 88-2472] p 18 A88-31389
JOHNSON, RICHARD L.
Initial results of integrated testing of a regenerative ECLSS at MSFC
[SAE PAPER 871454] p 41 A88-21114
JOHNSON, W.
European Polar Platform operations and logistics
[IAF PAPER 87-15] p 135 A88-15812
JONES, ELLEN F.
Automated space power distribution and load management p 67 A88-11950
JONES, J. J.
The Aeroassist Flight Experiment
[IAF PAPER 87-197] p 2 A88-15934
JONES, KEVIN
Social factors in space station interiors
p 46 N88-19888
JONES, R. E.
A life test of a 22-Newton (5-lbf) hydrazine rocket
[NASA-TM-100232] p 79 N88-11750
JONES, ROBERT E.
Water-propellant resistojets for man-tended platforms
[IAF PAPER 87-259] p 78 A88-15975
Space Station propulsion system technology
p 78 A88-21255
Space station propulsion
[NASA-TM-100216] p 79 N88-11746
JONES, V. L.
Emulating a flexible space structure Modeling
[NASA-TM-100320] p 30 N88-16812
Cost effective development of a national test bed
[NASA-TM-100321] p 31 N88-19585
JONES, WILLIAM B.
National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 1
[NASA-CR-172009-VOL-1] p 166 N88-14855
JONES, WILLIAM B., JR.
National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987. Volume 2
[NASA-CR-172009-VOL-2] p 166 N88-14874
JOSHI, PRAKASH
Shuttle experiments to measure the optical environments surrounding large space structures
[AIAA PAPER 88-0432] p 14 A88-22321
JOSHI, S. M.
Design of robust line-of-sight pointing control system for the SCOLE configuration p 54 A88-27367
JOSHI, S. P.
Control for energy dissipation in structures
[AIAA PAPER 88-2272] p 22 A88-32228
JOSHI, SURESH M.
Information prioritization for control and automation of space operations p 86 A88-27355
JOW, HONG N.
Information prioritization for control and automation of space operations p 86 A88-27355
JOYCE, JOSEPH
Space station assembly/servicing capabilities
p 125 N88-10100
JUANG, J.-N.
Low authority threshold control for large flexible structures
[AIAA PAPER 88-2270] p 22 A88-32226
JUANG, JER-NAN
Some experiences with the Eigensystem Realization Algorithm p 17 A88-29615
JUHASZ, ALBERT
Selection of high temperature thermal energy storage materials for advanced solar dynamic space power systems p 64 A88-11801
JUHASZ, ALBERT J.
Impact of thermal energy storage properties on solar dynamic space power conversion system mass
p 64 A88-11805
JULICH, PAUL
CAMERA: Expert System for Space Station communications and tracking system management
p 75 A88-15285

K

KABA, L.
Electrochemical processing of solid waste
[NASA-CR-182413] p 157 N88-15852
KABE, ALVAR M.
Mode shape identification and orthogonalization
[AIAA PAPER 88-2354] p 23 A88-32294
KAKAD, Y. P.
Dynamics of spacecraft control laboratory experiment (SCOLE) slew maneuvers
[NASA-CR-4098] p 57 N88-10092
Combined problem of slew maneuver control and vibration suppression
[NASA-CR-181537] p 59 N88-12817
KALIL, MICHAEL
Space station architectural elements model study
[REPT-31799] p 10 N88-19885
KAN, V.
Reconstruction of the vertical atmospheric temperature profile on the base of refraction measurements from the Salyut-7 orbital station p 131 A88-23930
KARAM, ROBERT D.
Outgassing of spacecraft composites
p 95 A88-31404
KARPOV, O. N.
Determination of cosmic-ray characteristics on Salyut-7 p 131 A88-28349
KASHIWASE, TOSHIO
Reduced order models of a large flexible spacecraft
[IAF PAPER 87-356] p 13 A88-16046
KASHYAP, R. L.
Control of gripper position of a compliant link using strain gauge measurements p 48 A88-14895
KASSING, D.
Satellite power systems under consideration by the United Nations p 74 N88-16773
Robotics servicing experiment p 93 N88-19529
Man-tended options for European space robotics
p 94 N88-19539
KASZUBOWSKI, MARTIN
Space station accommodations for lunar base elements: A study
[NASA-TM-100501] p 106 N88-14907
KATO, J.
Modal damping measurement of MOS-1 Solar Array Paddle p 13 A88-16292
KATOVSKAYA, A.
Cardiovascular adaptation to zero-g during a long term flight (237 days) on board the Salyut 7 Soviet space station (1984) p 158 N88-19920
KATS, L. N.
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment
p 145 N88-12917
KATSUTA, H.
Development scenario of H-II Orbiting Plane, HOPE
[IAF PAPER 87-210] p 48 A88-15943
KATZENBEISSER, R.
Expert system study for spacecraft management
[TL-2699-ISS-1] p 101 N88-15004
KAWADA, MASAKUNI
Development of a master slave manipulator system for space use p 86 A88-26975
KAWAMURA, K.
Development of a coupled expert system for the spacecraft attitude control problem p 61 N88-17223
KAWASHIMA, N.
Results from a series of tethered rocket experiments
p 111 A88-18634
KEATON, P. W.
A lunar laboratory p 106 A88-29196
KEDDY, E.
Integrated heat pipe-thermal storage system performance evaluation p 32 A88-11803
KEELEY, M. G.
Concept definition study for recovery of tumbling satellites. Volume 1: Executive summary, study results
[NASA-CR-179228] p 127 N88-14118
KEGEL, G.
On a knowledge based assisted system for highly autonomous control of experiment-manipulators in the Man-Tended Free Flyer p 92 N88-19505
KEIGLER, JOHN E.
Spacecraft Systems Working Group report
p 165 N88-10091

KELLNER, A.
EUREX D: An expert system for failure diagnosis and recovery in the TCS of the European retrievable carrier EURECA p 146 N88-16385
Mobile robot activity model for autonomous free flying platforms p 92 N88-19507
Treatment of unforeseen situations by online knowledge-based diagnostic systems p 93 N88-19511

KELLY, CHRISTINE M.
Automated Space Station procedure execution [AIAA PAPER 88-0443] p 99 A88-22329

KELLY, FREDERICK A.
Dynamics formulations for the real-time simulation of constrained motion p 60 N88-14872

KELLY, G. M.
Orbit lifetime characteristics for Space Station [AIAA PAPER 88-2490] p 55 A88-31399

KELLY, TERRY J.
Guidance and control 1987; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Jan. 31-Feb. 4, 1987 p 91 A88-16976

KEMPF, ROBERT F.
Proprietary rights and commercial use of space stations p 161 A88-13453

KENNEDY, JOE
Low-cost prototypes for human factors evaluation of Space Station crew equipment [IAF PAPER 87-553] p 152 A88-16170

KENT, PAUL C., II
Critical issues for establishment of a permanently-occupied lunar base [AD-A187128] p 107 N88-17567

KERRIDGE, JOHN
Astrophysics and the solar nebula p 118 N88-15355

KERSLAKE, T. W.
Structural assessment of a Space Station solar dynamic heat receiver thermal energy storage canister [AIAA PAPER 88-2487] p 72 A88-31396

KERSTEN, L.
European retrievable carrier Eureca servicing by Hermes p 139 A88-21256

KESLER, L. O.
Telerobotic controller development p 89 N88-16370

KESSELL, J. B.
Advanced solar receiver conceptual design study p 64 A88-11800

KESSLER, M.
Report on the scientific satellites of the European Space Agency [ESA-SP-1090] p 116 N88-10081

KHAN, EYOUB
Space station architectural elements model study. Space station human factors research review p 102 N88-19884

KHOLIN, S. F.
Medlab: A project of a medical laboratory in space p 159 N88-19946

KHOT, N. S.
Optimization of actively controlled structures using goal programming techniques p 53 A88-25797

KIDA, T.
A unified matrix approach applied to dynamic formulation of complex space structures with nonlinear hinge forces and torques [IAF PAPER 87-348] p 13 A88-16038

KIDA, TAKASHI
An experimental study on flexible spacecraft three-axis attitude control p 53 A88-26356
Formulation methods of rigid multibody systems for large space structures and some results of computer simulation [NAL-TR-942] p 30 N88-17730

KIDGER, NEVILLE
Endurance record broken p 136 A88-19899
Cosmonauts observe supernova p 144 A88-30169

KIEFER, RICHARD L.
Space environmental effects on polymeric materials [NASA-CR-182418] p 97 N88-15082
Space environmental effects on polymeric materials [NASA-CR-182454] p 97 N88-19879

KIENLEN, E. MICHAEL, JR.
Space station accommodations for lunar base elements: A study [NASA-TM-100501] p 106 N88-14907

KIM, D. S.
An efficient multilevel optimization method for engineering design [AIAA PAPER 88-2226] p 8 A88-32190

KIM, Y.
Reliability models for Space Station power system p 65 A88-11815

KING, C. B.
Analysis of a rotating advanced technology space station for the year 2025 [NASA-CR-178345] p 107 N88-19580

KINGDON, J.
Exobiology and botany facilities for EURECA p 148 N88-19798

KINRA, V. K.
Comparison of experimental techniques in the measurement of damping capacity of metal-matrix composites p 56 A88-31600

KIRILLOVA, F. M.
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment p 145 N88-12917

KISHIMOTO, K.
Dynamic power generation for solar power satellites [IAF PAPER 87-253] p 69 A88-15872

KJOLLER, KENDALL J.
Advanced materials technology '87; Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr. 6-9, 1987 p 1 A88-13126

KLEIN, K. E.
Implications of shiftwork in space for human physiology experiments p 129 N88-19942

KLEIN, KARL E.
The space life sciences research and application in Europe p 143 A88-29106

KLEIN, MARIAN
Solar-thermodynamic power systems in space p 72 A88-26150

KLINGELHOEFER, E. L.
Potentials of robotic operations on board the man-tended free-flyer [IAF PAPER 87-17] p 82 A88-15813

KLUS, W. J.
Space Station Mission Planning System (MPS) development study. Volume 1: Executive summary [NASA-CR-179202] p 4 N88-10047
Space Station Mission Planning System (MPS) development study. Volume 2 [NASA-CR-179200] p 4 N88-10048

KLUS, W. L.
Space Station Mission Planning Study (MPS) development study. Volume 3: Software development plan [NASA-CR-179203] p 4 N88-10049

KNIGHT, DOUGLAS R.
Fire-related medical science p 156 N88-12525

KNOEBEL, ARTHUR
Can space station software be specified through Ada? p 9 N88-15622

KOCH, DAVID G.
A telescope for high energy gamma-ray measurements in the Space Station era [AIAA PAPER 88-0652] p 114 A88-22485

KOEHLER-NAUMANN, W.
Eureca - European user-friendly retrievable carrier p 139 A88-21251

KOELLE, H. H.
A 50 year scenario for the utilization of space to improve the quality-of-life on earth p 164 A88-27856
Definition and economic evaluation of Space Solar Power Systems (SSPS), part 1 [ILR-MITT-184-1(1987)] p 73 N88-16189
Definition and economic evaluation of Space Solar Power Systems (SSPS), part 2 [ILR-MITT-184-2(1987)] p 73 N88-16190

KOIVO, A. J.
Control of gripper position of a compliant link using strain gauge measurements p 48 A88-14995

KOMOYAMA, K.
Proposal of adaptively controlled transmitting array for microwave power transmission in space p 53 A88-25854

KONKEL, CARL R.
Design and development of a computer-assisted ground control technique for Space Station robotics p 82 A88-15284
Telerobotics and orbital laboratories - An end-to-end analysis and demonstration [IAF PAPER 87-27] p 83 A88-15819

KOOI, B. W.
A DMAP for updating dynamic mathematical models with measured data [NLR-MP-86027-U] p 26 N88-10367

KOPPENWALLNER, G.
Aerothermodynamics - A key to new aerospace transport systems [DGLR PAPER 87-077] p 4 A88-32477

KOSMO, JOSEPH J.
Space suit extravehicular hazards protection development [NASA-TM-100458] p 157 N88-12927

KOVALENOK, V.
Observations of ocean and sea bottom relief from space p 143 A88-26099

KRIEDL, W.
X-band SAR for a European remote sensing payload p 117 N88-12142

KRIL, MICHAEL B.
Treatment bed microbiological control [SAE PAPER 871492] p 42 A88-21146

KRIM, MICHAEL H.
An advanced imaging space telescope concept [IAF PAPER 87-480] p 110 A88-16113

KRISHEN, KUMAR
Vision technology/algorithms for space robotics applications p 90 N88-17267

KRISHNA, R.
The dynamics and control of large space structures after the onset of thermal shock [IAF PAPER 87-251] p 49 A88-16041

KRISHNAN, PADMANABHAN
Translation and execution of distributed Ada programs - Is it still Ada? p 7 A88-21643

KRIZ, R. D.
Monitoring elastic stiffness degradation in graphite/epoxy composites p 14 A88-16173

KUBAN, D. P.
Traction-drive seven degrees-of-freedom telerobot arm: A concept for manipulation in space [DE87-010895] p 87 N88-11046

KUEBLER, M.
Orbital systems p 143 A88-26170

KULPA, VYGANTAS P.
Research and development at the Marshall Space Flight Center Neutral Buoyancy Simulator p 5 N88-10678

KUMARI, S. U.
Thermal design of the equipment platforms [IAF PAPER 87-06] p 34 A88-15806

KUNINAKA, HITOSHI
Numerical analysis of interaction of a high-voltage solar array with ionospheric plasma p 72 A88-27886

KUO, C. P.
Multiple boundary condition test (MBCT) - Identification with mode shapes [AIAA PAPER 88-2353] p 23 A88-32293

KUO, SHAU HERN
Optimal time free nodal transfers between elliptical orbits [IAF PAPER 87-325] p 79 A88-16021

KURAL, M. H.
Development and properties of aluminum-clad graphite/epoxy tubes for space structures [AIAA PAPER 88-2472] p 18 A88-31389

KURIBAYASHI, TADAO
A legal framework for Space Station activities p 160 A88-13447

KURIKI, KYOICHI
Numerical analysis of interaction of a high-voltage solar array with ionospheric plasma p 72 A88-27886

KURLAND, RICHARD
Advanced photovoltaic solar array design p 63 A88-11793

KUROKAWA, H.
Vapor compression distiller and membrane technology for water revitalization p 38 A88-17072

KURZHALS, PETER R.
Space Station services and design features for users [IAF PAPER 87-99] p 103 A88-15870

KUTZER, ANTS
The Columbus system aspects p 140 A88-21556
Project management in astronautics: From Spacelab to Columbus [MBB-URE-943/87] p 167 N88-17858

KUWAO, F.
Modal damping measurement of MOS-1 Solar Array Paddle p 13 A88-16292

KUWAO, FUMIHIRO
Vibration control of truss beam structures using axial force actuators [AIAA PAPER 88-2273] p 22 A88-32229

KUZ'MIN, MIKHAIL ANATOL'EVICH
Optimization of the energy systems of manned orbital stations - Mathematical modeling and selection of efficient structures p 68 A88-15684

KUZNETSOV, E. N.
Optimal reconfiguration of thermally distorted wire mesh reflectors for large space antennas [AIAA PAPER 88-2340] p 22 A88-32283

KWAK, MOON K.
Some thoughts on the convergence of the classical Rayleigh-Ritz method and the finite element method [AIAA PAPER 88-2269] p 21 A88-32225
Dynamics and control of spacecraft with retargetting flexible antennas [AIAA PAPER 88-2414] p 57 A88-32341

L

LABUS, THOMAS L.
Space Station Electrical Power System
[IAF PAPER 87-234] p 69 A88-15858

LACOMBE, J. L.
Control of in-orbit space manipulation
p 51 A88-16312
Robotic sensors and actuators for a service manipulator system. Volume 1: Executive summary
[MATRA-EPT/DT/VT187/120] p 87 N88-10041
Robotic sensors and actuators for a service manipulator system. Volume 2: Service Manipulator System (SMS) handbook
[MATRA-EPT/DT/VT187/227] p 87 N88-10042
Robotic sensors and actuators for a service manipulator system. Volume 3, phase A report and program plan
[MATRA-EPT/DT/VT187/228] p 87 N88-10043
Utilization of robotics and teleoperation for future in-orbit operations p 93 N88-19527

LACY, D. E.
Advanced solar receiver conceptual design study
p 64 A88-11800

LACY, DOVE E.
Selection of high temperature thermal energy storage materials for advanced solar dynamic space power systems p 64 A88-11801
Impact of thermal energy storage properties on solar dynamic space power conversion system mass
p 64 A88-11805

LAI, SHU T.
The effect of photoelectrons on boom-satellite potential differences during electron beam ejection
[AD-A190390] p 75 A88-20350

LAKE, MARK S.
Preliminary investigation of stability of a tri-stiffened slender strut
[NASA-TM-4034] p 31 N88-19548

LAKSHMANAN, P. K.
Dynamics and control of the tethered satellite system in the presence of offsets
[IAF PAPER 87-316] p 109 A88-16014
Dynamics and control of the Tethered Satellite System in the presence of offsets p 112 A88-20036

LAM, P. T.
Compensation of reflector antenna surface distortion using an array feed
[NASA-TM-100286] p 77 N88-18805

LANCE, NICK
Processes in construction of failure management expert systems from device design information
p 86 A88-24230

LAND, KEN
Telerobotic controller development p 89 N88-16370

LANGBEIN, D.
Allowable gravity-levels for Spacelab, Columbus and EURECA
[BF-R-66.525-2] p 132 N88-15084

LANGEMANN, M.
Study of a payload for Columbus Polar Platform Earth observation demonstration mission, executive summary
[ESA-CR(P)-2412] p 118 N88-10079

LANTZ, RENEE
An innovative exercise method to simulate orbital EVA work - Applications to PLSS automatic controls
[SAE PAPER 871475] p 154 A88-21130

LAPCHINE, L.
Antibiotic activity in space, results and hypothesis
p 159 N88-19952

LAPIERRE, HELENE
Structural model verification with LQG theory
[AIAA PAPER 88-2360] p 23 A88-32300

LAVIGNA, THOMAS A.
Satellite servicing in the Space Station era
p 121 A88-15268
Assembly of user systems at Space Station
p 121 N88-19490

LAWRENCE, DALE A.
Stability analysis for alternative force control schemes as applied to remote space teleoperation
[AAS PAPER 87-043] p 51 A88-16998

LAWRENCE, GEORGE F.
AUTOPLAN - A PC-based automated mission planning tool p 7 A88-20486

LAZARETH, O. W.
Particle bed reactor propulsion vehicle performance and characteristics as an orbital transfer rocket
p 78 A88-22707

LAZAREV, A.
Observations of ocean and sea bottom relief from space p 143 A88-26099

LEBOUAR, P. H.
Study of fault tolerant techniques for satellite data handling
[FTT/REP/0001/SAAB] p 101 N88-13860

LEBOUAR, PH.
Promising concepts for ground-to-orbit experiment teleoperation p 93 N88-12518

LEBRETON, J. P.
Laboratory simulation of the electrodynamic interactions of a tethered satellite with an ionospheric plasma
[FSI-86-3] p 119 N88-15822

LEBRETON, J.-P.
Report on the scientific satellites of the European Space Agency
[ESA-SP-1090] p 116 N88-10081

LECUREUX, Y.
Operational utilization of the polar platforms
[IAF PAPER 87-116] p 109 A88-15882

LEDOUX, PAUL W.
Spacecraft material flammability testing and configurations p 96 N88-12529

LEE, C.
On-orbit servicing and cost effectiveness of Columbus polar platform concepts
[IAF PAPER 87-42] p 123 A88-15831

LEE, C. P.
The utilisation of the Columbus Polar Platform
[IAF PAPER 87-98] p 162 A88-15869
Study of large solar arrays (SOLA), phase 2A
[BAE-SS/1139] p 74 N88-17106

LEE, FRED C.
Computer modeling and simulation of a 20kHz ac distribution system for Space Station p 66 A88-11827

LEE, K. Y.
Distributed systems approach to the identification of flexible structures p 15 A88-22606
System identification of flexible structures
[AIAA PAPER 88-2361] p 23 A88-32301

LEE, M. C.
Electrochemically regenerable carbon dioxide/moisture control technology for an Advanced Extravehicular Mobility Unit
[SAE PAPER 871470] p 41 A88-21126

LEE, S. W.
Compensation of reflector antenna surface distortion using an array feed
[NASA-TM-100286] p 77 N88-18805

LEE, W. Y.
Optimal trajectories for aeroassisted, noncoplanar orbital transfer. II - LEO-to-LEO transfer
[IAF PAPER 87-329] p 49 A88-16024

LEGER, L.
Space station contamination considerations
p 131 N88-10859

LEGER, L. J.
Long-life assurance for Space Station - Is it an issue?
[AIAA PAPER 88-2489] p 43 A88-31398

LEGER, LUBERT
High intensity 5 eV O-atom exposure facility for material degradation studies p 96 N88-10847

LEGER, LUBERT J.
Assessment of external contamination for Space Station scientific payloads
[SAE PAPER 871476] p 130 A88-21131

LEGOSTAEV, V. P.
Development experience of the attitude control system using single-axis control moment gyros for long-term orbiting space stations
[IAF PAPER 87-04] p 48 A88-15804
The passive attitude motion of the orbital stations Salyut-6 and Salyut-7
[IAF PAPER 87-355] p 49 A88-16045

LEGRAND, SUE
Access control for a safety critical distributed system interface set
[AIAA PAPER 87-3083] p 100 A88-26211

LEINWEBER, DAVID
Controlling real-time processes on the Space Station with expert systems p 84 A88-21634

LEISEIFER, H.-P.
Columbus ECLSS
[SAE PAPER 871430] p 139 A88-21083

LEISER, DANIEL B.
Thermal response of integral multicomponent composites to a high-energy aerothermodynamic heating environment with surface temperature to 1600 K
p 10 A88-12591

LEKAN, JACK
Communications payload concepts for geostationary facilities
[NASA-TM-100154] p 76 N88-13513

LEMAIGNEN, L.
European EVA requirements and space suit design
[IAF PAPER 87-41] p 152 A88-15830

LEMAIGNEN, LOUIS
Evolutive concept of an EVA space suit
[SAE PAPER 871518] p 154 A88-21163

LEMPRIERE, B. M.
Space station integrated wall damage and penetration damage control. Task 5: Space debris measurement, mapping and characterization system
[NASA-CR-179291] p 30 N88-17588

LENKEVICH, MICHAEL J.
Materials selection as related to contamination of spacecraft critical surfaces p 95 A88-26965

LEONARD, J. T.
A smoke removal unit
[SAE PAPER 871449] p 153 A88-21108

LEPANTO, JANET A.
Efficient placement of structural dynamics sensors on the space station
[NASA-CR-172015] p 25 N88-10120

LESINA, M. E.
Construction of a full solution for an integrable case of the problem of the motion of two coupled bodies
p 115 A88-26687
Construction of a full solution to the problem of the relative motion of a system of two bodies
p 115 A88-26688

LESZKIEWICZ, SUZAN J.
Efficient spacecraft formationkeeping with consideration of ballistic coefficient control
[AIAA PAPER 88-0375] p 124 A88-22277

LETAW, JOHN R.
Radiation hazards on space missions
p 130 A88-22919

LETCHWORTH, ROBERT
Space Station - A focus for the development of structural dynamics scale model technology for large flexible space structures
[AIAA PAPER 88-2483] p 19 A88-31362

LETOULLEC, CH.
Cardiovascular adaptation to zero-g during a long term flight (237 days) on board the Salyut 7 Soviet space station (1984) p 158 N88-19920

LEVADOU, F.
Discharge prevention of geosynchronous orbit conductive thermal control materials and grounding systems p 76 N88-11732

LEVIN, E. M.
Stability of the steady motions of an electromagnetic tether system in orbit p 107 A88-11234

LEVIN, G. M.
The flight demonstration program and selection process p 126 N88-10871

LEVIN, GEORGE C.
NASA Office of Space Flight (OSF) in-orbit servicing program p 126 N88-19498

LEVIN, GEORGE M.
An overview of the Office of Space Flight satellite servicing program plan
[IAF PAPER 87-35] p 122 A88-15825

LEVIN, ZEV
Atmospheric science p 5 N88-15357

LEVY, LEON
External surface charging mechanisms
p 132 N88-11718
Discharge phenomena p 132 N88-11723

LEWIS, F.
On the hierarchical control of the Space Station common module thermal system p 33 A88-14980

LEWIS, JAMES L.
Space Station viewing requirements
[SAE PAPER 861754] p 1 A88-10155

LEWIS, WILLIAM C., JR.
Inventory behavior at remote sites p 5 N88-14873

LI, FEIYUE
Minimum time attitude slewing manouvers of a rigid spacecraft
[AIAA PAPER 88-0675] p 52 A88-22505

LI, W. W.
Observations of ions generated on or near satellite surfaces
[AIAA PAPER 88-0434] p 130 A88-22323

LIENING, F.
Controlled Ecological Life Support Systems (CELSS) physiochemical waste management systems evaluation
[NASA-CR-177422] p 45 N88-14626

LIEVRE, J.
Solar sailing attitude control of large geostationary satellite p 50 A88-16280

LIN, CHIN
Environmental control and life support system requirements and technology needs for advanced manned space missions
[SAE PAPER 871433] p 39 A88-21096

LIN, CHIN H.
Space Station Active Thermal Control System modeling
[AIAA PAPER 88-0475] p 36 A88-22349

LIN, DOUGLAS
Astrophysics and the solar nebula
p 118 N88-15355

Planetary science p 5 N88-15356

LIN, JIGUAN GENE
Control design challenges of large space systems and spacecraft control laboratory experiment (SCOLE)
[NASA-CR-178392] p 58 N88-11735

LIN, Y. C.
Control for energy dissipation in structures
[AIAA PAPER 88-2272] p 22 A88-32226

LINDBERG, C.
Support of life science research in space by the DFVLR Microgravity User Support Center (MUSC)
[IAF PAPER 87-544] p 152 A88-16162

LINDNER, D. K.
A survey of decentralized control techniques for large space structures p 16 A88-27359

LINTON, ARTHUR T.
Recent developments in water quality monitoring for Space Station reclaimed wastewaters
[SAE PAPER 871447] p 40 A88-21107

LINTZ, ANDREW
Shuttle experiments to measure the optical environments surrounding large space structures
[AIAA PAPER 88-0432] p 14 A88-22321

LIPPAY, A. L.
Definition of the EUROSIM simulation subsystem p 148 N88-19532

LIPPIATT, THOMAS F.
Potential applications of expert systems and operations research to space station logistics functions
[NASA-CR-180473] p 67 N88-12342

LIPS, K. W.
Approaches and possible improvements in the area of multibody dynamics modeling
[NASA-CR-179227] p 28 N88-14087

LISSAC, PIERRE
Looking ahead for materials and processes; Proceedings of the Eighth SAMPE (European Chapter) International Conference, La Baule, France, May 18-21, 1987 p 94 A88-20701

LIZIUS, D.
Radiation characteristics of offset radial rib reflector antennas p 34 A88-17586

LLEWELLYN, CHARLES
Space station accommodations for lunar base elements. A study
[NASA-TM-100501] p 106 N88-14907

LO, R. E.
Solar-thermal OTVs in comparison with electrical and chemical propulsion systems
[IAF PAPER 87-199] p 77 A88-15836

LOEB, H. W.
Solar- and nuclear electric propulsion for high energy orbits
[IAF PAPER 87-198] p 77 A88-15835

LOEILLET, C.
Promising concepts for ground-to-orbit experiment teleoperation p 93 N88-19518

LOESER, H.
Design and development of the life support subsystem of a laboratory model of the Botany Facility
[SAE PAPER 871519] p 43 A88-21164

LOEWY, ROBERT G.
Studies of the structural dynamic behavior of satellite antenna system
[AD-A193526] p 28 N88-14121

LOLLAR, LOUIS F.
Automated load management for spacecraft power systems p 67 A88-11863

LOMAN, VLADIMIR IVANOVICH
Deployable umbrella reflector antennas p 143 A88-27743

LONGHURST, F.
The Columbus space segment
[IAF PAPER 87-66] p 136 A88-15845

LONGHURST, FRANK
Columbus Space Segment definition p 133 A88-15293
The Columbus system baseline and interfaces p 134 A88-15297

LONGONI, F.
Applicability of A.I. techniques to the Space Station, a study case - Development of an expert system for on board fault management
[IAF PAPER 87-30] p 83 A88-15822

LOOSCH, MINDRIG R.
Status of ongoing government-level negotiations on space stations p 132 A88-13444

LORENZ, RALPH D.
Debris hazard poses future threat p 131 A88-24946

LORENZINI, ENRICO C.
Recent developments in gravity gradiometry from the Space-Shuttle-borne tethered satellite system p 112 A88-21531
Analytical investigation of the dynamics of tethered constellations in Earth orbit (phase 2)
[NASA-CR-179219] p 117 N88-12533

LOUMBADI, A.
Modeling and emulation of distributed flexibility in a spaceborne manipulator p 83 A88-16309

LOUIS, J. F.
Binary mercury/organic Rankine cycle power systems p 63 A88-11795

LOUVIERE, ALLEN J.
Water-propellant resistojets for man-tended platforms
[IAF PAPER 87-259] p 78 A88-15975

LOVEJOY, V. D.
Dynamics and control of a planar truss actuator p 55 A88-31564

LOZAR, CHARLES C.
State-of-the-art technologies for construction in space: A review
[AD-A188412] p 91 N88-19483

LUDWIG, K.-P.
Study on long term evolution towards European manned space flight. Volume 1: Executive summary
[MBB-RA3-004/87-VOL-1] p 147 N88-17689

LUDWIG, KLAUS-PETER
External payload servicing: Operational requirements and technology p 129 N88-19541

LUI, C. Y.
Simultaneous structural and control optimization via linear quadratic regulator eigenstructure assignment p 29 N88-13622

LUKASIK, KRYSTYNA
Educational and pedagogical importance of astronautics
[IAF PAPER 87-520] p 162 A88-16146

LUM, HENRY
Building intelligent systems - Artificial intelligence research at NASA Ames Research Center p 62 A88-15300
Progress towards autonomous, intelligent systems
[IAF PAPER 87-31] p 83 A88-15823

LUMIA, R.
NASA/NBS (National Aeronautics and Space Administration/National Bureau of Standards) standard reference model for Telerobot Control System Architecture (NASREM)
[PB88-124773] p 92 N88-17999

LUNDQUIST, CHARLES A.
Acceleration measurement and management on a space station
[IAF PAPER 87-364] p 50 A88-16049

LUST, R. V.
Control-augmented structural synthesis
[AIAA PAPER 88-1014] p 55 A88-28043

LUTZ, J. D.
Finite-element model for the thermoelastic analysis of large composite space structures p 14 A88-19632

LYMAN, PETER
International Space Station operations. Nine dimensions - October 13, 1987
[IAF PAPER 87-13] p 122 A88-15810
Space Station Program implications from the viewpoint of the Space Station Operations Task Force
[IAF PAPER 87-62] p 123 A88-15858

LYNN, DAVID
Earth observation from the Space Station p 112 A88-20067

M

MA, SHING
Three parallel computation methods for structural vibration analysis
[AIAA PAPER 88-2391] p 24 A88-32323

MACCONOCHIE, IAN
Capture-ejector satellites p 108 A88-11726

MACCONOCHIE, IAN O.
Potential for on-orbit manufacture of large space structures using the pultrusion process
[NASA-TM-4016] p 29 N88-13388

MACGILLIVRAY, CHARLES SCOTT
Design and development of the truss assembly fixture for Space Station assembly operations
[AIAA PAPER 88-2455] p 18 A88-31380

MACHIDA, KAZUO
Development of a master slave manipulator system for space use p 86 A88-26975

MACKENZIE, JOHN D.
Novel composite materials for space structures and systems p 10 A88-13188

MACKINNON, IAN
Astrophysics and the solar nebula p 116 N88-15355

MACKINNON, IAN D. R.
Progress toward a cosmic dust collection facility on space station
[NASA-CR-182427] p 121 N88-19568

MACSY, ALFRED C.
Performance considerations for the astrometric telescope facility on the phase 1 space station
[NASA-TM-100040] p 45 N88-14898

MADAYEV, L.
Concept definition study for recovery of tumbling satellites. Volume 1: Executive summary, study results
[NASA-CR-179229] p 127 N88-14118

MADDEN, P.
A free-flying power plant for a manned space station p 70 A88-16308

MADSEN, R. A.
Catalytic processes for space station waste conversion
[NASA-CR-177423] p 44 N88-10491

MAEKAWA, SHIGERU
Toward new materials processing in space p 2 A88-21572

MAGGI, M.
Research on Electrodynamic Tether Effects (RETE) experiment Electrical Ground Support Equipment (EGSE)
[IFSI-87-2] p 100 N88-13378

MAGNANI, P. G.
In-orbit automatic assembly of reticular structures p 92 N88-19491

MAH, H. W.
Dynamics and control during slewing maneuvers
[IAF PAPER 87-253] p 49 A88-16043
A relatively general formulation for studying dynamics of the Space Station based MRMS with applications
[AIAA PAPER 88-0674] p 52 A88-22504

MAHAJAN, UMESH
Three parallel computation methods for structural vibration analysis
[AIAA PAPER 88-2391] p 24 A88-32323

MAHANEY, JACK
Self-shadowing effects on the thermal-structural response of orbiting trusses p 32 A88-11734

MAHEFKEY, E. T.
Roll-out-fin expandable space radiator concept p 36 A88-30320

MAHEFKEY, E. THOMAS
Thermal Control Working Group report p 36 N88-10094

MAINS, RICHARD
OSSA Space Station waste inventory
[SAE PAPER 871413] p 39 A88-21078

MAKAROV, VLADIMIR IVANOVICH
Mankind and space p 164 A88-29410

MAKEEV, E. V.
Sensitivity analysis and optimal design for large unrestrained structures
[IAF PAPER 87-321] p 12 A88-16019

MALIN, JANE T.
Processes in construction of failure management expert systems from device design information p 66 A88-24230

MAMODE, A.
The high performance solar array GSR3
[SNIAS-872-422-108] p 73 N88-13814

MANCUSO, GIUSEPPE
Columbus pressurized modules: Maintenance and supply concepts - Approach and development for a Space Station long term support
[IAF PAPER 87-66] p 137 A88-15860

MANKAMYER, MELANIE M.
Technology advancements to improve crew productivity in space p 151 A88-15283

MARAL, GERARD
Prospects on future EVA communications
[AIAA PAPER 88-0767] p 76 A88-27542

MARAN, STEPHEN P.
The Solar Maximum Mission repair - Lessons learned p 124 A88-21653

MARCHAL, CHRISTIAN
Optimal time free nodal transfers between elliptical orbits
[IAF PAPER 87-325] p 79 A88-16021
Solar sails and the Ariel satellite - Scientific applications and techniques p 106 A88-26864

MARCHAL, P.
Dynamic testing of a docking system p 62 N88-19516

MARCHAL, PH.
Control techniques for rendez-vous and docking p 51 A88-16311

MARGLE, JANICE M.
Spacecraft Fire Safety
[NASA-CP-2478] p 158 N88-12520

MARKLAND, C. A.
Tethers: An outline of a new concept for Earth observation p 120 N88-16791

MARRIOTT, RICHARD S.
Outgassing data for selecting spacecraft materials
[NASA-RP-1124] p 95 N88-10117

MARSDEN, R.
Report on the scientific satellites of the European Space Agency
[ESA-SP-1090] p 116 N88-10081
MARSHALL, JOHN R.
Planetary science p 5 N88-15358
MARSHALL, PAUL F.
Expert system applications in spacecraft subsystem controllers p 90 N88-17254
MARSHALL, T. S.
Thermal environment simulator for vacuum testing of large spacecraft p 36 A88-25979
MARTEL, FRANCK
Coorbitation of free-flyers
[IAF PAPER 87-14] p 108 A88-15811
MARTIN, ANTHONY R.
Concept studies for a laser powered Orbital Transfer Vehicle
[IAF PAPER 87-200] p 77 A88-15907
MARTIN, FRANKLIN D.
Space station: Leadership for the future
[NASA-PAM-509/8-87] p 185 N88-10072
MARTIN, J. A.
Design techniques for 20K Hz power converters p 66 A88-11822
MARTIN, JAMES A.
Capture-ejector satellites p 108 A88-11726
MARTIN, W. N.
Focus of attention in systems for visual monitoring of experiments p 112 A88-21658
MARTINEZ-VAL, R.
A preliminary study of a fluid science laboratory for space station (Columbus). Part 4: Executive summary
[NLR-TR-87023-L-PT-4] p 79 N88-11072
MARTINEZ, I.
A preliminary study of a fluid science laboratory for space station (Columbus). Part 4: Executive summary
[NLR-TR-87023-L-PT-4] p 79 N88-11072
MARTINOVIC, ZORAN NAUM
Sensitivity of active vibration control to structural changes and model reduction p 30 N88-17683
MARUYA, K. A.
Contamination control concepts for space station customer servicing p 131 N88-10860
MASSARI, S.
Robotic intelligence issues for space manipulator monitoring, control programming p 92 N88-19504
MASUBUCHI, K.
An initial study of remotely manipulated stud welding for space applications p 96 A88-21274
MATHEWS, MICHAEL
Efficient spacecraft formationkeeping with consideration of ballistic coefficient control
[AIAA PAPER 88-0375] p 124 A88-22277
MATIJEVIC, J. R.
The NASA telerobot technology demonstrator p 95 A88-21651
MATSUBARA, S.
Development scenario of H-II Orbiting Plane, HOPE
[IAF PAPER 87-210] p 48 A88-15943
MATSUI, FUSAKI
Development of on-board satellite communications equipment in the Geostationary Platform era
[IAF PAPER 87-495] p 110 A88-16136
MATSUMOTO, K.
Sunlight supply and gas exchange systems in microalgal bioreactor p 44 N88-12258
MAUTE, P.
Analysis of RVD operations in manned space missions p 61 N88-19494
MCALLISTER, J. G.
Space station onboard propulsion system: Technology study
[NASA-CR-179233] p 80 N88-15006
MCANULTY, MICHAEL
Report from the MPP Working Group to the NASA Associate Administrator for Space Science and Applications
[NASA-TM-87819] p 100 N88-11402
MCCAIN, H. G.
NASA/NBS (National Aeronautics and Space Administration/National Bureau of Standards) standard reference model for Telerobot Control System Architecture (NASREM)
[PB86-124773] p 92 N88-17099
MCCARTHY, K. K.
Space station onboard propulsion system: Technology study
[NASA-CR-179233] p 80 N88-15006
MCCLURE, JOHN
Autonomous management of the Space Station electric energy system p 71 A88-21641
MCCORMACK, P. D.
Artificial gravity - A countermeasure for zero gravity
[IAF PAPER 87-033] p 105 A88-16156
MCCORMICK, M. P.
Remote sensing Earth's surface and atmosphere; Proceedings of Workshop X and the Tropical Meeting of the 29th COSPAR Plenary Meeting, Toulouse, France, June 30-July 11, 1986 p 111 A88-17026
MCCOY, MICHAEL S.
A human performance modelling approach to intelligent decision support systems p 90 N88-17242
MCCRAY, S. B.
Development of a non-phase-change waste-water treatment subsystem
[SAE PAPER 871514] p 43 A88-21159
MCDANIEL, M.
An AI approach for scheduling space-station payloads at Kennedy Space Center p 90 N88-16425
MCELVEEN, R. P.
Carbon Dioxide observational platform system (CO-OPS): Feasibility Study
[NASA-CR-179225] p 118 N88-14113
Feasibility study of a carbon dioxide observational platform system. Volume 2: Programmatics
[NASA-CR-180454] p 119 N88-14114
MCFADDEN, D.
Performance characteristics of moving belt radiators p 33 A88-12006
MCFETERS, GORDON A.
Consequences of bacterial resistance to disinfection by iodine in potable water
[SAE PAPER 871489] p 42 A88-21143
MCGOWAN, PAUL E.
Space Station - A focus for the development of structural dynamics scale model technology for large flexible space structures
[AIAA PAPER 88-2483] p 19 A88-31382
MCHALE, MICHAEL P.
Pumped two-phase ammonia thermal bus: test bed
[SAE PAPER 871442] p 34 A88-21104
MCKAY, C. P.
Exobiology and life science p 118 N88-15358
MCKAY, CHRISTOPHER P.
Microgravity Particle Research on the Space Station
[NASA-CP-2496] p 118 N88-15354
MCKAY, SCOTT J.
Comparative study of cable construction for 20 kHz power distribution p 66 A88-11831
MCKINNEY, ROYCE L.
Space Station services and design features for users
[IAF PAPER 87-99] p 103 A88-15870
MCKNIGHT, DARREN S.
Artificial space debris p 130 A88-17944
MCLAUCHLAN, ROBERT A.
Dynamics, control and sensor issues pertinent to robotic hands for the EVA retriever system p 88 N88-14976
MCNEIL, W. J.
Analysis of geophysical data bases and models for spacecraft interactions
[AD-A184809] p 100 N88-13375
MCNEIL, WILLIAM J.
The effect of photoelectrons on boom-satellite potential differences during electron beam ejection
[AD-A190390] p 75 A88-26350
MCQUADE, T. E.
(M,N)-approximation - A system simplification method p 54 A88-27402
MEASE, K. D.
Optimal trajectories for aeroassisted, noncoplanar orbital transfer. II - LEO-to-LEO transfer
[IAF PAPER 87-328] p 49 A88-16024
MEDANIC, J. V.
Structural decomposition approach to design of robust decentralized controllers for large scale systems p 53 A88-27358
MEDLER, E. H.
Contamination control concepts for space station customer servicing p 131 N88-10860
MEIROVITCH, L.
Maneuvering and vibration control of flexible spacecraft p 52 A88-22932
MEIROVITCH, LEONARD
Some thoughts on the convergence of the classical Rayleigh-Ritz method and the finite element method
[AIAA PAPER 88-2269] p 21 A88-32225
Dynamics and control of spacecraft with retargeting flexible antennas
[AIAA PAPER 88-2414] p 57 A88-32341
MEISSINGER, HANS E.
Cost-effective orbit transfer modes for satellite retrieval and servicing p 61 N88-19489
MEISSINGER, HANS F.
Technology requirements for telerobotic satellite servicing in space p 93 N88-19536
MELKUMIAN, L. V.
Determination of cosmic-ray characteristics on Salyut-7 p 131 A88-28349
MENEES, GENE P.
Aeroassisted-vehicle design studies for a manned Mars mission
[IAF PAPER 87-433] p 50 A88-16093
Aeroassisted-vehicle design studies for a manned Mars mission
[NASA-TM-100031] p 58 N88-11790
MENG, P. R.
A life test of a 22-Newton (5-lbf) hydrazine rocket
[NASA-TM-100232] p 79 N88-11750
MENG, PHILLIP R.
Space Station propulsion system technology p 78 A88-21255
MERCADAL, MATHIEU
Survey on large scale system control methods
[NASA-CR-181556] p 59 N88-13374
MERLINA, P.
Tethered space elevator - Possible applications and demonstrative experiments
[IAF PAPER 87-49] p 109 A88-15834
MERLO, M.
Columbus pressurized module utilization study, executive summary
[CS-RP-AI-027] p 146 N88-15005
MERRIGAN, M.
Integrated heat pipe-thermal storage system performance evaluation p 32 A88-11803
MERRIGAN, MICHAEL A.
An evaluation of heat pipe radiators incorporating pumped liquid return p 33 A88-11810
MESEROLE, J. S.
Slosh dynamics in a toroidal tank p 78 A88-27588
MESHKOV, V. M.
Space near and far p 143 A88-27734
MESSIDORO, PIERO
Columbus pressurized module verification p 145 N88-10842
MIAN, A.
Telescience testbedding for life science missions on the Space Station
[AIAA PAPER 88-0446] p 86 A88-22332
MICHAELIS, HORST
Future European ground segment p 133 A88-15279
Future European ground segment
[MBB-UR-E-676-87] p 142 A88-23969
MICHAUD, MICHAEL A. G.
Negotiating the Space Station p 160 A88-13445
MICHAUD, ROGER
Life sciences biomedical research planning for Space Station
[SAE PAPER 871464] p 153 A88-21122
MIDDLETON, J. A.
Canada's Space Station Program p 142 A88-24980
MIELE, A.
Optimal trajectories for aeroassisted, noncoplanar orbital transfer. II - LEO-to-LEO transfer
[IAF PAPER 87-328] p 49 A88-16024
MIGNE, P.
Cardiovascular adaptation to zero-g during a long term flight (237 days) on board the Salyut 7 Soviet space station (1984) p 158 N88-19920
MIKOLAJ, PETER
Capabilities and special features concerning structural optimization of spacecraft structures
[IAF PAPER 87-320] p 12 A88-16018
MIKULAS, MARTIN M., JR.
Continuum modeling of large lattice structures: Status and projections
[NASA-TP-2767] p 28 N88-14115
MILDICE, J.
The ac power system testbed
[NASA-CR-175068] p 72 N88-11948
MILDICE, J. W.
Control considerations for high frequency, resonant, power processing equipment used in large systems p 47 A88-11829
MILLER, CHRIS
Low-cost prototypes for human factors evaluation of Space Station crew equipment
[IAF PAPER 87-553] p 152 A88-18170
MILLER, CRAIG F.
Telerobotics and orbital laboratories - An end-to-end analysis and demonstration
[IAF PAPER 87-27] p 83 A88-15819
MILLER, D.
Toluene stability Space Station Rankine power system p 63 A88-11794
MILLER, DAVID W.
Active modification of wave reflection and transmission in flexible structures p 16 A88-27595
MILLER, EDWARD F.
An allotment planning concept and related computer software for planning the fixed satellite service at the 1988 space WARC
[NASA-TM-100244] p 165 N88-11944

MILLER, J. B.
Feasibility study for gas-grain simulation facility
[NASA-CR-177468] p 28 N88-13954
MILLER, KEITH W.
NASA-STD-3000, Man-System Integration Standards - The new space human engineering standards
[IAF PAPER 87-550] p 152 A88-16167
MILLER, LADONNA
Life sciences biomedical research planning for Space Station
[SAE PAPER 871464] p 153 A89-21122
MILLER, P. S.
Performance evaluation of SPE electrolyzer for Space Station life support
[SAE PAPER 871451] p 40 A89-21111
MILLER, WILLIAM D.
Automated space power distribution and load management p 87 A89-11980
MILLS, RAYMOND A.
Structural Assembly Demonstration Experiment (SADE)
[NASA-CR-179205] p 26 N88-10958
MINEMOTO, M.
An experimental study of the Bosch and the Sabatier CO2 reduction processes
[SAE PAPER 871517] p 43 A89-21162
MISAWA, MASAYOSHI
Analytical and experimental investigations for satellite antenna deployment mechanisms
[AIAA PAPER 88-2225] p 76 A88-32189
MISRA, A. K.
Dynamics and control of the tethered satellite system in the presence of offsets
[IAF PAPER 87-316] p 109 A88-16014
On control of tethered satellite systems p 110 A88-16294
Dynamics and control of the Tethered Satellite System in the presence of offsets p 112 A88-20036
MISRA, AJAY K.
Fluoride salts and container materials for thermal energy storage applications in the temperature range 973 - 1400 K p 32 A89-11804
MITANI, K.
Vapor compression distiller and membrane technology for water revitalization p 39 A89-17072
MITARAI, GENYO
Space life sciences in Japan p 164 A89-29107
MITCHELL, J. R.
Design-to-performance p 2 A89-16295
MITSUGI, JIN
Research and development of the tension truss antenna
[IAF PAPER 87-317] p 12 A88-16015
MIURA, KOKYO
Research and development of the tension truss antenna
[IAF PAPER 87-317] p 12 A88-16015
MIYAKE, M.
An initial study of remotely manipulated stud welding for space applications p 96 A89-31274
MIYAKE, R. N.
Large deployable reflector thermal characteristics in low earth orbits
[AIAA PAPER 88-0471] p 36 A88-22347
MIYAKE, SHOJIRO
Analytical and experimental investigations for satellite antenna deployment mechanisms
[AIAA PAPER 88-2225] p 76 A88-32189
MIYASAKA, KIMIO
Development of on-board satellite communications equipment in the Geostationary Platform era
[IAF PAPER 87-495] p 110 A88-16136
MOATES, DEBORAH J.
EASE/ACCESS ground processing at Kennedy Space Center p 27 N88-10877
MOATTI, N.
Antibiotic activity in space, results and hypothesis p 159 N89-19952
MODI, V. J.
Dynamics and control of the tethered satellite system in the presence of offsets
[IAF PAPER 87-316] p 109 A88-16014
Dynamics and control during slewing maneuvers
[IAF PAPER 87-353] p 49 A88-16043
On control of tethered satellite systems p 110 A88-16294
Dynamics and control of the Tethered Satellite System in the presence of offsets p 112 A88-20036
A relatively general formulation for studying dynamics of the Space Station based MRMS with applications
[AIAA PAPER 88-0674] p 52 A88-22504
MOE, RUD V.
Explorer Platform on-orbit servicing operations p 121 N88-19526
MOG, ROBERT A.
Optimization techniques applied to passive measures for in-orbit spacecraft survivability
[NASA-CR-178216] p 5 N88-12532
MOGSTAD, T.
A simple model for the initial phase of a water plasma cloud about a large structure in space
[AIAA PAPER 88-0430] p 95 A88-22320
MOK, E. Y.
An orbiting control station for free-flying teleoperators - Preliminary design methodology p 51 A88-21647
MOK, EVA
Crew interface with a telerobotic control station p 91 N89-17273
MONTPERT, PHILIPPE
The Eureca space platform p 143 A89-29858
MOOK, D. JOSEPH
Estimation and identification of nonlinear dynamic systems
[AIAA PAPER 88-2271] p 57 A88-32227
MOOKHERJI, TRIP
Materials processing twin experiment
[AIAA PAPER 88-0346] p 183 A88-22295
MOOKHERJI, TRIPTY
Polymer crystal growth facility concept for Space Station laboratory module p 1 A88-15314
MOORE, RAYMOND
Polymer crystal growth facility concept for Space Station laboratory module p 1 A88-15314
MOREL, DONALD E.
Development of composite facets for the surface of a space-based solar dynamic concentrator p 70 A88-16230
MORGAN, C. J.
A life test of a 22-Newton (5-lbf) hydrazine rocket
[NASA-TM-100232] p 79 N88-11750
MORGAN, E. L.
Rapid toxicity detection in water quality control utilizing automated multispecies biomonitoring for permanent space stations p 44 N88-10848
MORGAN, HENLEY D.
Momentum management and attitude control design for a Space Station p 55 A88-29253
MORGENTHALER, D. R.
Design and analysis of passively damped large space structures p 56 A88-31574
MORI, K.
Sunlight supply and gas exchange systems in microalgal bioreactor p 44 N88-12258
MORISHITA, Y.
JEM present project status
[IAF PAPER 87-63] p 135 A88-15842
MORITA, Y.
Dynamics and control during slewing maneuvers
[IAF PAPER 87-353] p 49 A88-16043
A relatively general formulation for studying dynamics of the Space Station based MRMS with applications
[AIAA PAPER 88-0674] p 52 A88-22504
MOROSOW, G.
The integration of a mesh reflector to a 15-foot box truss structure. Task 3: Box truss analysis and technology development
[NASA-CR-179229] p 91 N88-18941
MORSE, A. F.
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment p 145 N88-12917
MORREN, W. EARL
Water-propellant resistojets for man-tended platforms
[IAF PAPER 87-258] p 78 A88-15875
Space station propulsion
[NASA-TM-100016] p 79 N88-11748
MORRIS, W. DOUGLAS
A space transportation system operations model
[NASA-TM-100481] p 8 N88-14999
MORSE, D. F.
Experiments in advanced control concepts for space robotics - An overview of the Stanford Aerospace Robotics Laboratory
[AAS PAPER 87-044] p 83 A88-16099
MORTAZAVI, P. L.
Status of the Space Station water reclamation and management subsystem design concept
[SAE PAPER 871510] p 42 A89-21158
MORTON, MARK HARRISON
Natural control of flexible space structures p 58 N88-12534
MOSER, THOMAS L.
NASA and the Space Station - Current Status
[IAF PAPER 87-84] p 161 A88-15843
MOSIER, FRANCES L.
The 1987 Get Away Special Experimenter's Symposium
[NASA-CP-2500] p 121 N88-17691
MOSKOVITS, MARTIN
Physics and chemistry p 118 N88-15359
MOTOHASHI, S.
Modal damping measurement of MOS-1 Solar Array Paddle p 13 A88-16292
MOTOHASHI, SHOICHI
Vibration control of truss beam structures using axial force actuators
[AIAA PAPER 88-2273] p 22 A88-32229
MOUNT, FRANCES E.
Space Station viewing requirements
[SAE PAPER 861704] p 1 A88-10155
MUDGE, TREVOR N.
Translation and execution of distributed Ada programs - Is it still Ada? p 7 A89-21643
MULLIN, J.
The evolution of space power systems technology
[IAF PAPER 87-226] p 68 A88-15952
MUNTZ, E. P.
True energy atmospheric simulator for low earth orbit spacecraft
[AIAA PAPER 88-0727] p 3 A88-22549
MURDOCH, J.
A teleoperated manipulator system concept for unmanned platforms p 94 N88-19537
MURPHY, GREGORY D.
An analysis of the effect of aeroassist maneuvers on orbital transfer vehicle performance
[NASA-TM-89117] p 150 N88-14116
MURRAY, ROBERT M.
Manned Mars mission accommodation by the evolutionary Space Station
[IAF PAPER 87-439] p 105 A88-16097
MUSI, P.
Electrical current flow across the TSS - The core equipment and other related technical issues
[IAF PAPER 87-252] p 109 A88-15971
MUZIUKIN, M. A.
Synthesis of the flexible structures of complex systems p 15 A89-27148

N

NAGEM, RAYMOND J.
Natural frequencies and structural integrity assessment of large space structures
[AD-A186139] p 29 N88-15001
NAHRA, HENRY K.
Low Earth orbit environmental effects on the space station photovoltaic power generation systems
[NASA-TM-100230] p 73 N88-12429
NAKANISHI, SHIGEO
Space environmental considerations for a long-term cryogenic storage vessel p 80 N88-15833
NAKATANI, ICHIRO
Scanning laser radar system for rendezvous and docking in space
[IAF PAPER 87-53] p 48 A88-15838
NALETTE, TIMOTHY A.
Development of a regenerable humidity and CO2 control system for an advanced EMU
[SAE PAPER 871471] p 41 A89-21127
NAMKOONG, D.
Solar dynamic organic Rankine cycle heat rejection system simulation p 65 A89-11808
NAPOLITANO, LUIGI G.
Prospects and problems in microgravity fluid science p 2 A89-21383
NARAYANA, K. BADARI
Thermal design of the equipment platforms
[IAF PAPER 87-06] p 34 A88-15806
NASON, JOHN R.
High pressure water electrolysis for the Space Station
[SAE PAPER 871473] p 41 A89-21128
NATARAJU, B. S.
Deployment dynamics of accordian type of deployable solar arrays considering flexibility of closed control loops
[IAF P[illegible]] p 11 A89-15974
NA[illegible]
[illegible] dispersion-strengthened platinum with [illegible]
[NASA-TP-27[illegible]] p 79 N88-12536
NATORI, MICHIHIKO
Vibration control of truss beam structures using axial force actuators
[AIAA PAPER 88-2273] p 22 A88-32229
NAUCK, J.
The DFS platform and its applications
[IAF PAPER 87-470] p 138 A88-16119
NDESOUZA, PETRONIO
Construction aspects of testbeds for attitude control systems emulation of artificial satellites
[INPE-4283-PRE/1155] p 61 N88-18616
NEASE, ARDELL
Implementation of expert system technology on the Space Station p 99 A89-21654

241

GERI, GIAI
A telescope for high energy gamma-ray measurements in the Space Station era
[AIAA PAPER 88-0652] p 114 A88-22485
GELLESSEN, E.
Design and verification of the FLECS test structure p 54 A88-27779
GELLESSEN, W.
The Eureca concept and its importance in preparing the Columbus Programme p 140 A88-21524
GELLESSEN, WOLFGANG
Enhanced Eureca configuration operations p 134 A88-15295
GELSON, WALTER C.
Orbit design for a space ambulance vehicle p 149 A88-15313
GEMIR, D.
Control of gripper position of a compliant link using strain gauge measurements p 18 A88-14395
GENBOLD, D. D.
Development of a non-phase-change on-site water treatment subsystem
[SAE PAPER 871514] p 43 A88-21159
GENKLINK, DENNIS
Repair of Salyut 7 p 143 A89-25943
GENYMAN, JOHN W.
Carbofiex - A new general purpose pitch-based carbon fiber p 94 A88-13252
GENYMAN, P. A.
Knowledge-based simulation p 152 N88-16404
GGUYEN, CHARLES C.
Optimal control of large space structures via generalized inverse matrix
[NASA-CR-182236] p 59 N88-13867
Cartesian path control of a two-degree-of-freedom robot manipulator
[NASA-CR-182231] p 88 N88-13868
NGUYEN, DUC T.
The component-mode method in a parallel computer environment
[AIAA PAPER 88-2439] p 9 A88-32355
NGUYEN, H. P.
Rendezvous and Docking Verification (RVDV) and on-orbit demonstration, executive summary
[RVD-RVDV-FR-AS-01] p 127 N88-14120
Analysis of RVD operations in manned space missions p 61 N88-19494
NGUYEN, H.-P.
Rendezvous and docking (RVD) verification and demonstration in-orbit p 62 N88-19521
NGUYEN, T. A.
Cooperating expert systems for Space Station power distribution management p 71 A88-21633
NGUYEN, T. K.
Concept definition study for recovery of tumbling satellites. Volume 1: Executive summary, study results
[NASA-CR-179229] p 127 N88-14119
NICHOLAS, JOHN M.
Small groups in orbit - Group interaction and crew performance on Space Station p 151 A88-15348
Crew productivity issues in long-duration space flight
[AIAA PAPER 88-0444] p 154 A88-22330
NICOGOSSIAN, A. E.
Artificial gravity - A countermeasure for zero gravity
[IAF P/PER 87-533] p 105 A88-18156
NIHEI, T.
Experimental study for carbon dioxide removal system in Space Station
[SAE PAPER 871516] p 43 A88-21161
NIKOLSKII, G. M.
Stratospheric luminescence observed from the Salyut-7 station p 144 A88-30076
NINOMIYA, KEIKEN
Scanning laser radar system for rendezvous and docking in space
[IAF PAPER 87-53] p 48 A88-15838
NISHIOKA, KENJI
Performance considerations for the astrometric telescope facility on the phase 1 space station
[NASA-TM-100640] p 40 N88-14888
Workshop on Technology Development Issues for the Large Deployable Reflector (LDR)
[NASA-CP-2407] p 52 N88-25235
NITTA, KEIJI
An overview of Japanese CELSS research activities p 44 N88-12367
NIXON, DAVID
Low-cost prototypes for human factors evaluation of Space Station crew equipment
[IAF PAPER 87-553] p 152 A88-18170
Space station group activities habitability module study: A synopsis p 8 N88-19898
NOGUN, STEVEN L.
Vapor transport furnace for organic crystals and films
[AIAA PAPER 88-0160] p 113 A88-22113
NOOR, AHMED K.
Continuum modeling of large lattice structures: Status and projections
[NASA-TP-2787] p 26 N88-14015
NORDLEY, GERALD O.
Space based nuclear microwave electric propulsion p 76 A88-22726
NORMAN, A. M.
Space station propulsion technology
[NASA-CR-179260] p 90 N88-15835
NORMAN, SUSAN D.
Theoretical considerations in designing operator interfaces for automated systems p 85 A88-21658
NORRIS, G. A.
Sensor and actuator selection for optimal closed-loop performance in the presence of correlated noise p 54 A88-27397
NORWOOD, C. W.
Observations of ions generated on or near satellite surfaces
[AIAA PAPER 88-0434] p 130 A88-22323
NUTH, JOSEPH
Astrophysics and the solar nebula p 118 N88-15305

O

O'NEILL, J.
Automated testing and integration of heterogeneous systems p 33 A88-11874
O'NEILL, MARK J.
Development of an advanced photovoltaic concentrator system for space applications p 85 A88-11812
OBAYASHI, T.
Results from a series of tethered rocket experiments p 111 A88-19634
OBERLE, B.
Aspects and possibilities of an integrated energy and media supply system on H2/O2 basis for manned space stations in the low earth orbit
[IAF PAPER 87-241] p 38 A88-15963
OCKELS, W. J.
Absorptive tethers - A first test in space p 115 A88-27781
ODA, M.
Long-term strategy of space science in Japan p 143 A88-29195
ODONNELL, JOHN
Report from the MPP Working Group to the NASA Associate Administrator for Space Science and Applications
[NASA-TM-87919] p 150 N88-11402
OELKER, G.
A new Italian proposal for a Space Station Assembly and Servicing Vehicle (ASMV)
[IAF PAPER 87-57] p 139 A88-15827
OELKER, GUSTAVO
Trends to reduce development and operation costs for experiments of the future space laboratory
[IAF PAPER 87-100] p 105 A88-15871
OGLE, K. Y.
The Space Station air revitalization subsystem design concept
[SAE PAPER 871448] p 40 A88-21108
OHKAMI, Y.
A unified matrix approach applied to dynamic formulation of complex space structures with nonlinear hinge forces and torques
[IAF PAPER 87-348] p 13 A88-18038
OHKAMI, YOSHIAKI
An experimental study on flexible spacecraft three-axis attitude control p 53 A88-28358
Formulation methods of rigid multibody systems for large space structures and some results of computer simulation
[NAL-TR-942] p 30 N88-17730
OHLER, PETER C.
The distributed AI system for the dynamic allocation and management of power (DAISY-DAMP) testbed p 84 A88-21638
OHTOMO, ISAO
Research and development of the tension truss antenna
[IAF PAPER 87-317] p 12 A88-18015
OHYA, H.
Sunlight supply and gas exchange systems in microalgal bioreactor p 44 N88-13258
OKAMOTO, D.
A unified matrix approach applied to dynamic formulation of complex space structures with nonlinear hinge forces and torques
[IAF PAPER 87-348] p 13 A88-18038
OKAMOTO, OSAMU
An experimental study on flexible spacecraft three-axis attitude control p 57 A88-28358
Formulation methods of rigid multibody systems for large space structures and some results of computer simulation
[NAL-TR-942] p 30 N88-17730
OLDHAM, S. L.
High temperature resistant compliant modified epoxies p 95 A88-29565
OLDS, JOHN R.
A conceptual design for a single-stage-to-orbit Space Station Service Vehicle
[IAF PAPER 87-57-07] p 2 A88-18071
A conceptual design for a single-stage-to-orbit Space Station service vehicle
[AIAA PAPER 88-0560] p 3 A88-22063
OLESON, M.
Controlled Ecological Life Support Systems (CELSS) physicochemical waste management systems evaluation
[NASA-CR-177402] p 45 N88-14826
OLESON, M. W.
Lighting considerations in a controlled environmental life support system
[SAE PAPER 871435] p 39 A88-21098
OLESON, MELVIN
Controlled Ecological Life Support Systems (CELSS) conceptual design option study
[NASA-CR-177421] p 44 N88-14825
OLSEN, R. C.
Observations of ions generated on or near satellite surfaces
[AIAA PAPER 88-0434] p 130 A88-22323
OLSON, R. L.
Lighting considerations in a controlled environmental life support system
[SAE PAPER 871435] p 39 A88-21098
Controlled Ecological Life Support Systems (CELSS) physicochemical waste management systems evaluation
[NASA-CR-177402] p 45 N88-14826
OLSON, RICHARD L.
Controlled Ecological Life Support Systems (CELSS) conceptual design option study
[NASA-CR-177421] p 44 N88-14825
OLSZEWSKI, MITCHELL
Optimization and analysis of lithium hydride thermal energy storage device configurations for space power applications p 64 A88-11802
OLTHOF, H.
Space science with Columbus p 141 A88-21367
Report on the scientific satellites of the European Space Agency
[ESA-SP-1096] p 116 N88-13081
Space station based interferometry p 116 N88-13629
OLVER, A. D.
Radiation characteristics of offset radial rib reflector antennas p 54 A88-17588
ON, FRANK J.
ENVIRONET database on vibroacoustics
[AIAA PAPER 88-0010A] p 99 A88-22011
ONODA, JUNJIRO
Two-dimensionally deployable 'SHOF' truss
[IAF PAPER 87-319] p 12 A88-18017
ORDWAY, FREDERICK I., III
Project Horizon - An early study of a lunar outpost
[IAF PAPER 87-459] p 105 A88-18237
OREN, J. A.
Space erectable radiator system development
[AIAA PAPER 88-0469] p 36 A88-22345
ORTEGA, JAMES
Solution of structural analysis problems on a parallel computer
[AIAA PAPER 88-2297] p 22 A88-32240
ORWOLL, ROBERT A.
Space environmental effects on polymeric materials
[NASA-CR-182418] p 97 N88-15082
Space environmental effects on polymeric materials
[NASA-CR-182454] p 97 N88-15879
OSEGUEDA, ROBERTO
Nondestructive construction error detection in large space structures
[AIAA PAPER 88-2460] p 18 A88-31360
OSER, H.
The European Space Agency's role in life sciences and research in space p 148 N88-13894
OSHMAN, YAAKOV
Optimal on-line measurement system configuration strategies
[AIAA PAPER 88-2341] p 8 A88-32264
OSTHUY, GERMAIN
Structural model verification with LDC theory
[AIAA PAPER 88-2380] p 23 A88-32300
OTABURO, W. S.
Telerobotic controller development p 89 N88-16370
OTSU, YUICHI
Development of on-board satellite communications equipment in the Geostationary Platform era
[IAF PAPER 87-495] p 110 A88-18138

OTSUJI, K.
Experimental study for carbon dioxide removal system in Space Station
[SAE PAPER 871516] p 43 A89-21181
An experimental study of the Bosch and the Sabatier CDE reduction processes
[SAE PAPER 871517] p 43 A89-21182
OUAZZANI, JALIL
Analysis of low gravity tolerance of model experiments for space station: Preliminary results for directional solidification
[NASA-CR-182607] p 10 N89-19048
OVCHINNIKOV, V. S.
Experience of the Salyut-7 propulsion system (PS) repair operations
[AF PAPER 87-87] p 137 A88-15861
OXENBERG, SHELDON
Semiautonomous control for satellite servicing
[AIAA PAPER 87-2952] p 91 A89-12573
OYABA, K. I.
Results from a series of tethered rocket experiments
p 111 A89-19634
OZGUNER, UMIT
Active vibration control on the OSU flexible beam
p 15 A88-27357

P

PAC, J. L.
Identification and control of flexible structures
p 54 A89-27768
PADALKAR, S.
Development of a coupled expert system for the spacecraft attitude control problem p 61 N89-17223
PADEKEN, D.
Support of life science research in space by the DFVLR Microgravity User Support Center (MUSC)
[AF PAPER 87-544] p 152 A88-16182
Microgravity User Support Center (MUSC) for EURECA, Spacelab and Columbus missions p 149 N89-19947
PAGANA, E.
Large inflatable, space-rigidized antenna reflectors - Land mobile services development
[AF PAPER 87-315] p 12 A88-16013
PAHL, D. A.
A life test of a 22-Newton (5-lbf) hydrazine rocket
[NASA-TM-100232] p 79 N89-11750
PAILLOUX, ALAIN
Spacecraft surface exposure to atomic oxygen in low Earth orbit p 96 N89-11715
PAIROT, J.
Columbus preparatory program. Payload element study on a technology demonstration mission, executive summary
[CS-RP-AI-018] p 145 N89-19080
PALGUTA, T.
Preliminary analysis of an integrated logistics system for OSSA payloads
[NASA-CR-4114] p 6 N88-19477
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 1: Executive summary
p 6 N88-19478
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 2: OSSA integrated logistics support strategy p 6 N88-19479
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 3: OSSA integrated logistics support planning document p 6 N88-19480
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 4: Supportability analysis of the 1.8m centrifuge p 6 N88-19481
PALMER, EVERETT
Cooperative human-machine fault diagnosis
p 60 A89-21459
PALMUCCI, P.
Study of mobile communications payload for Columbus Polar Platforms
[ITS-TR-056A/86] p 76 N89-10220
PALUSZEK, M.
A free-flying power plant for a manned space station
p 70 A89-16309
PANDOLFI, A.
Study of mobile communications payload for Columbus Polar Platforms
[ITS-TR-056A/86] p 76 N89-10220
PANOSSIAN, HAGOP V.
Model order reduction techniques in large space structure applications
[AIAA PAPER 88-2467] p 24 A89-33359
PAPPA, RICHARD S.
Some experiences with the Eigensystem Realization Algorithm p 17 A89-29915
PARISH, RICHARD
Design of an ammonia two-phase Prototype Thermal Bus for Space Station
[SAE PAPER 871506] p 35 A89-21152
PARK, J.
SAFIRE - A novel high resolution cooled spectrometer for atmospheric research
[AF PAPER 87-137] p 159 A88-15894
PARK, K. C.
Structural tailoring and feedback control synthesis - An interdisciplinary approach
[AIAA PAPER 88-2294] p 21 A89-32177
PARK, WILLIAM T.
Automatic planning research applied to orbital construction p 124 A88-21837
PARKER, G. H.
Binary mercury/organic Rankine cycle power systems p 63 A89-11795
PARKINSON, R. C.
Possibilities for a European evolutionary space infrastructure
[AF PAPER 87-69] p 105 A88-15847
PARR, C. H.
Long-life assurance for Space Station - Is it an issue?
[AIAA PAPER 88-2469] p 43 A89-31398
PATAT, F.
Cardiovascular adaptation to zero-g during a long term flight (237 days) on board the Salyut 7 Soviet space station (1984) p 138 N89-19929
Cardiac and peripheral circulation assessment by ultrasound on 3 astronauts during two 7-day space flights (1982 Salyut-7 - 1985 STS-51G) p 158 N89-19921
PATERRA, FRANK C.
AUTOPLAN - A PC-based automated mission planning tool p 7 A89-20486
PATRICK, MERRELL
Three parallel computation methods for structural vibration analysis
[AIAA PAPER 88-2391] p 24 A88-32303
PATTEN, W. N.
Dynamics and control of a planar truss actuator
p 55 A89-31584
PATTERSON, DAVID W.
Preliminary design of the Space Station internal thermal control system
[SAE PAPER 871505] p 35 A89-21151
PATTON, A. D.
Reliability models for Space Station power system
p 65 A88-11815
PAUL, WERNER H.
Integrity control of carbon fiber reinforced plastics (CFRP) structural elements. Conclusion with respect to the control methodology of CFRP primary structures in manned space flight and the implications to the design, analysis and testing of CFRP structural elements, executive summary
[MBB-TR-RB517-014/85] p 97 N86-16824
PAULES, GRANVILLE E.
International Space Station operations. New dimensions - October 13, 1987
[AF PAPER 87-13] p 122 A88-15810
Space Station Program implications from the viewpoint of the Space Station Operations Task Force
[AF PAPER 87-82] p 123 A88-15858
PAULSEN, PHILLIP E.
Oxidation and protection of fiberglass-epoxy composite masts for photovoltaic arrays in the low Earth orbital environment
[NASA-TM-100839] p 97 N88-18734
PEACOCK, A.
Report on the scientific satellites of the European Space Agency
[ESA-SP-1090] p 116 N86-10381
PEARCE, TONY
Stress rupture behavior of carbon-fiber metal-lined pressure vessels for 30-year operation in space
[AIAA PAPER 88-2479] p 19 A88-31391
PEARSON, SHIRLEY J.
EVA construction and repair of tubular systems on Space Station
[AIAA PAPER 88-2436] p 125 A88-31381
PECK, S. J.
Advanced radiator concepts utilizing honeycomb panel heat pipes
[NASA-CR-173917] p 57 N88-12747
PELKA, E. J.
Space Station assembly - Techniques and structures
p 104 A88-26420
PENNINGTON, JACK E.
System architecture for telerobotic servicing and assembly tasks p 60 A89-21649
PERARNAUD, D.
Study of fault tolerant techniques for satellite data handling
[PTT/REP/0991/SAAB] p 101 N86-13660
PERKINS, W. A.
Use of communicating expert systems in fault diagnosis for Space Station applications p 43 A88-21625
PERKINS, W. R.
Structural decomposition approach to design of robust decentralized controllers for large scale systems
p 53 A88-27358
PERKINSON, DON
Orbital transfer vehicle studies overview
p 192 N88-15801
PERRY, JOHN
Controlling real-time processes on the Space Station with expert systems p 64 A88-21634
PERSICO, R.
Applicability of A.I. techniques to the Space Station, a study case - Development of an expert system for on-board fault management
[AF PAPER 87-30] p 93 A88-15822
PERSON, JAMES
Shuttle experiments to measure the optical environments surrounding large space structures
[AIAA PAPER 88-0432] p 14 A88-23321
PESAVENTO, PETER
Sputnik's heirs - What the Soviets are doing in space
p 133 A88-14911
PESTOV, IGOR' DMITRIEVICH
Mankind and space p 184 A89-29410
PETERS, H. H.
Development of a non-phase-change waste-water treatment subsystem
[SAE PAPER 871514] p 43 A88-21159
PETERS, PALMER N.
A measurement of the angular distribution of 5 ev atomic oxygen scattered off a solid surface in earth orbit
p 139 A88-15886
PETERSON, G. P.
Thermal contact conductance in the presence of thin metal foils
[AIAA PAPER 88-0466] p 35 A88-22342
PETERSON, G. R.
Design concepts for bioreactors in space
p 45 N88-17179
PETROSINO, FABRIZIO
Columbus operation and utilization
p 191 A88-21582
PFEIFER, K.
Stress and deformation analysis and tests of composite structures for space application
[AF PAPER 87-312] p 12 A88-16011
PFEIFFER, B. R. K.
An overview of the current Earth observation programs (Europe, USA, and Japan) p 167 N88-16778
PFLUG, JOHN
Pinhole occulter experiment
[NASA-CR-179208] p 115 N88-11481
PHAB-VAN-DIEP, G. C.
True energy atmospheric simulator for low earth orbit species
[AIAA PAPER 88-0727] p 3 A88-23547
PHILLIPS, ROBERT W.
Biotechnology opportunities on Space Station
[SAE PAPER 871468] p 154 A88-21124
PIERSON, DUANE L.
Inflight microbial analysis technology
[SAE PAPER 871493] p 42 A88-21147
Test results of a shower water recovery system
[SAE PAPER 871512] p 42 A88-21158
PIETRAS, JOHN V.
Network management for the Space Station Information System
[AIAA PAPER 88-0116] p 99 A88-23082
PIGG, D. E.
Long-life assurance for Space Station - Is it an issue?
[AIAA PAPER 88-2469] p 43 A88-31398
PIKE, G. H. S.
Commercial launch systems - The foreseeable future for Ariane
p 191 A88-15480
PILONI, V.
Study of mobile communications payload for Columbus Polar Platforms
[ITS-TR-056A/86] p 76 N89-10220
PINSON, LARRY D.
Recent advances in structural dynamics of large space structures
[AF PAPER 87-51] p 11 A88-15838
Recent advances in structural dynamics of large space structures
[NASA-TM-100513] p 26 N88-10967
PISTOLE, CARL G.
A concept for standard load center automation
p 67 A88-11807
PIEZZON, MICHAEL F., JR.
Development of an advanced photovoltaic concentrator system for space applications p 65 A88-11812
PIVIROTTO, DONNA L.
Telerobotics p 86 N89-19090

243

PIVIROTTO, DONNA SHIRLEY
NASA's Telerobotics R & D Program - Status and future directions
[IAF PAPER 87-24] p 82 A88-15816
PIZZICHEMI, J. C.
Pumped two-phase ammonia thermal bus test bed
[SAE PAPER 871442] p 34 A88-21104
PLAGNE, A.
The high performance solar array GSR3
[SNIAS-872-422-108] p 73 N88-13814
PLATT, GORDON K.
Technology demonstrator program for Space Station Environmental Control Life Support System
[SAE PAPER 871456] p 41 A88-21115
PLEVIN, JOHN
Earth observation from the Space Station
p 112 A88-20067
PODSADNIK, VLADIMIR
USSR export possibilities in the field of space hardware
[SAE PAPER 871342] p 133 A88-14368
POEHLS, ROBERT J.
Application of advanced automation techniques in the Space Station electrical power system
p 75 A88-11855
POLEY, WILLIAM A.
Communications payload concepts for geostationary facilities
[NASA-TM-100154] p 76 N88-12513
POMATHIOD, L.
Laboratory simulation of the electrodynamic interactions of a tethered satellite with an ionospheric plasma
[FSI-86-3] p 119 N88-15822
PONCHAK, DENISE S.
An allotment planning concept and related computer software for planning the fixed satellite service at the 1988 space WARC
[NASA-TM-100244] p 165 N88-11944
PONNAPPAN, R.
Roll-out fin expandable space radiator concept
p 36 A88-30320
PONZI, UGO
Numerical and numerical-analytical interfaces in structural thermal-dynamic interactive problems
[IAF PAPER 87-322] p 49 A88-16020
POOLE, EUGENE
Solution of structural analysis problems on a parallel computer
[AIAA PAPER 85-4287] p 22 A88-32240
PORAN, FARHAD J.
Cartesian path control of a two-degree-of-freedom robot manipulator
[NASA-CR-182331] p 68 N88-13808
POPE, EDWARD J. A.
Novel composite materials for space structures and systems
p 10 A88-13188
POPE, J.
Study of large solar arrays (SOLA), phase 2A
[BAE-SS/1109] p 74 N88-17106
POPOV, V. L.
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment
p 141 N88-12917
POSPIESZCZYK, HANS-J.
Evolution of data management systems from Spacelab to Columbus
[MBB-UR-E-968-87] p 99 A88-23981
POSPISIL, M.
Plasmod power station
[IAF PAPER 87-250] p 69 A88-15969
POSPISILOVA, L.
Plasmod power station
[IAF PAPER 87-250] p 69 A88-15969
POTAPOV, IU. V.
Determination of cosmic-ray characteristics on Salyut-7
p 131 A88-28349
POTTIER, J. M.
Cardiovascular adaptation to zero-g during a long term flight (237 days) on board the Salyut 7 Soviet space station (1984) p 158 N88-19920
Cardiac and peripheral circulation assessment by ultrasound on 3 astronauts during two 7-day space flights (1982 Salyut-7 - 1985 STS 51G) p 158 N88-19921
POURCELOT, L.
Cardiovascular adaptation to zero-g during a long term flight (237 days) on board the Salyut 7 Soviet space station (1984) p 158 N88-19920
Cardiac and peripheral circulation assessment by ultrasound on 3 astronauts during two 7-day space flights (1982 Salyut-7 - 1985 STS 51G) p 158 N88-19921
POWELL, D.
Study of fault tolerant techniques for satellite data handling
[FTT/REP/0001/SAAB] p 101 N88-13860
POWELL, FEROLYN T.
Environmental control and life support system requirements and technology needs for advanced manned space missions
[SAE PAPER 871433] p 39 A88-21096
POWELL, J. DAVID
Kinetic isolation tether experiment
[NASA-CR-182458] p 120 N88-16810
POWELL, J. R.
Particle bed reactor propulsion vehicle performance and characteristics as an orbital transfer rocket
p 78 A88-22707
PRAIZEY, J.-P.
Metallurgy laboratory for Columbus, executive summary
[SNIAS-813-CA/TS] p 145 N88-10980
PREESE, J. R.
Concept definition study for recovery of tumbling satellites. Volume 1: Executive summary, study results
[NASA-CR-179228] p 127 N88-14118
PREISS, H.
Columbus ECLSS
[SAE PAPER 871430] p 139 A88-21093
PREUKSCHAT, A. W.
Satellite assembly in geostationary orbit: A plug-and-socket concept
p 127 N88-16769
PREUMONT, ANDRE
Spillover stabilization of large space structures
[AIAA PAPER 88-2484] p 55 A88-31393
PREWO, KARL M.
Carbon fiber reinforced glass matrix composites for space based applications
[AD-A184355] p 96 N88-12546
PRICE, D. MARVIN
Optimization techniques applied to passive measures for in-orbit spacecraft survivability
[NASA-CR-179216] p 5 N88-12532
PRICE, DON F.
Thermoelectric integrated membrane evaporation subsystem testing
[SAE PAPER 871446] p 40 A88-21106
PRICE, DONALD F.
Test results of a shower water recovery system
[SAE PAPER 871512] p 42 A88-21158
PRICE, JOHN M.
The tethered satellite electrodynamics experiment project
[AIAA PAPER 88-0690] p 114 A88-22516
PRICE, K. M.
Communications satellite systems operations with the space station. Volume 3: Supplementary technical report
[NASA-CR-180875] p 77 N88-16794
PRICE, KENT M.
Economic benefits of the Space Station to commercial communication satellite operators
[IAF PAPER 87-622] p 163 A88-16215
The economics of satellite retrieval
[AIAA PAPER 88-0843] p 164 A88-27584
PRIEM, RICHARD J.
Study of industry requirements that can be fulfilled by combustion experimentation aboard space station
[NASA-CR-180814] p 167 N88-19377
PRIMEAUX, GARY R.
Life sciences biomedical research planning for Space Station
[SAE PAPER 871464] p 153 A88-21122
Assessment of external contamination for Space Station scientific payloads
[SAE PAPER 871476] p 130 A88-21131
PRINS, J. J. M.
EPOS: European Proximity Operations Simulation
p 147 N88-19515
PRITCHARD, E. BRIAN
Manned Mars mission accomodation by the evolutionary Space Station
[IAF PAPER 87-438] p 105 A88-16097
PRONK, C. N. A.
Definition of the EUROSIM simulation subsystem
p 148 N88-19532
PROVOST, DAVID E.
The Flight Telerobotic Servicer (FTS) - A focus for automation and robotics on the Space Station
[IAF PAPER 87-25] p 92 A88-15817
PRUETT, DAVID
Space Station Information System - Concepts and international issues
[IAF PAPER 87-76] p 96 A88-15851
PULS, J.
Potentials of robotic operations on board the man-tended free-flyer
[IAF PAPER 87-17] p 92 A88-15813
PURVES, B.
Automated testing and integration of heterogeneous systems
p 33 A88-11874
On the hierarchical control of the Space Station common module thermal system
p 33 A88-14980
PURVES, R. B.
Foundation: Transforming data bases into knowledge bases
p 102 N88-16423
PUSKAR, M. C.
Performance evaluation of SPE electrolyzer for Space Station life support
[SAE PAPER 871451] p 40 A88-21111
PUTNEY, WILLIAM W.
Comparative study of cable construction for 20 kHz power distribution
p 66 A88-11831
PYLE, BARRY H.
Consequences of bacterial resistance to disinfection by iodine in potable water
[SAE PAPER 871489] p 42 A88-21143

Q

QUEIJO, M. J.
Analysis of a rotating advanced-technology space station for the year 2025
[NASA-CR-178345] p 107 N88-19580
QUINN, A.
An orbiting control station for free-flying teleoperators - Preliminary design methodology
p 51 A88-21647
QUINN, R. D.
Maneuvering and vibration control of flexible spacecraft
p 52 A88-22932

R

RACCA, GIUSEPPE D.
Thermal control definition of Columbus pressurized modules
[SAE PAPER 871483] p 139 A88-21138
RADCLIFFE, CLARK J.
Control of distributed parameter systems with spillover using an augmented observer
p 16 A88-27377
RAGALLER, D. R.
Toluene stability Space Station Rankine power system
p 63 A88-11794
Solar dynamic organic Rankine cycle heat rejection system simulation
p 65 A88-11808
RAJU, J. A. S.
Mirrabooka X-ray detector and spacecraft design study
p 108 A88-15811
RAMAKER, RUSSELL A.
Design of low order controllers for robust disturbance rejection in large space structures
[AD-A185202] p 59 N88-13376
RANDALL, ROGER M.
Orbiter transfer vehicle concept definition and system analysis study. Volume 4: Space station accommodations. Revision 1
[NASA-CR-179293] p 130 N88-18609
Orbital transfer vehicle concept definition and system analysis study. Volume 4, Appendix A: Space station accommodations. Revision 1
[NASA-CR-179294] p 110 N88-18610
RANDHAWA, MANJIT S.
Automatic antenna switching design for extra Vehicular Activity (EVA) communication system
p 77 N88-14883
RANEY, WILLIAM P.
International cooperation in the Space Station
p 142 A88-21573
RANIERI, R.
Fault tolerant onboard implementation of control procedures in tethered satellite
p 110 A88-16285
RAO, M. D.
Experimental study of damping of graphite epoxy composite material of the Space Telescope truss system
p 56 A88-31605
RAO, S. S.
Optimization of actively controlled structures using goal programming techniques
p 53 A88-25797
RAPLEY, C. G.
Swath altimetry of oceans and terrain
p 115 A88-27938
RASCHKE, E.
Remote sensing: Earth's surface and atmosphere; Proceedings of Workshop X and the Topical Meeting of the 26th COSPAR Plenary Meeting, Toulouse, France, June 30-July 11, 1986
p 111 A88-17026
RASMUSSEN, D.
Water management requirements for animal and plant maintenance on the Space Station
[SAE PAPER 871469] p 41 A88-21125
Telescience testbedding for life science missions on the Space Station
[AIAA PAPER 88-0446] p 86 A88-22332
RASMUSSEN, DARYL N.
OSSA Space Station waste inventory
[SAE PAPER 871413] p 39 A88-21079

RAST, M.
Technical aspects of future ocean colour remote sensing p 119 N88-16298
RATH, W.
European retrievible carrier Eureca servicing by Hermes p 139 A88-21256
RAUSCH, G. H.
The Resource Module p 140 A88-21559
RAUSHENBAKH, B. V.
Thirty years of the space age p 162 A88-16074
RAY, A. K.
Comparison of experimental techniques in the measurement of damping capacity of metal-matrix composites p 56 A88-31600
RAY, ASOCK
Information prioritization for control and automation of space operations p 86 A88-27355
RAY, C. D.
The Space Station air revitalization subsystem design concept
[SAE PAPER 871448] p 40 A88-21136
RAY, R. J.
Development of a non-phase-change waste-water treatment subsystem
[SAE PAPER 871514] p 43 A88-21159
RAYMUS, STEVEN
Semiautonomous control for satellite servicing
[AIAA PAPER 87-2952] p 81 A88-12573
READ, J. Y.
Use of communicating expert systems in fault diagnosis for Space Station applications p 43 A88-21635
REDD, FRANK J.
An optically tethered and controlled satellite system
[IAF PAPER 87-50] p 109 A88-15835
Measurement and modeling of joint damping in space structures
[AIAA PAPER 88-2449] p 17 A88-31370
REDD, L. R.
Space station onboard propulsion system: Technology study
[NASA-CR-179233] p 80 N88-15006
REDDY, A. S. S. R.
The dynamics and control of large-flexible space structures, part 10
[NASA-CR-182426] p 29 N88-15830
REESE, T. G.
Tethers in space handbook
[NASA-CR-181371] p 119 N88-14123
REESE, TERRENCE G.
GEO platform servicing - Technology solutions
[IAF PAPER 87-08] p 122 A88-15808
REIBALDI, G. G.
The in-orbit technology demonstration programme of the European Space Agency
[IAF PAPER 87-09] p 135 A88-15803
Large inflatable, space-rigidized antenna reflectors - Land mobile services development
[IAF PAPER 87-315] p 12 A88-16013
Future in-orbit technology demonstrations p 14 A88-21521
REICHARD, K.
A survey of decentralized control techniques for large space structures p 16 A88-27359
REID, DANIEL F.
Space station platforms p 116 N88-10086
Attitude Control Working Group report p 57 N88-10099
REID, DONALD H.
Space Station pressure wall repair techniques
[AIAA PAPER 88-2488] p 19 A88-31397
REITZ, G.
Support of life science research in space by the DFVLR Microgravity User Support Center (MUSC)
[IAF PAPER 87-544] p 152 A88-16162
Radiation problems in manned space flight with a view to the Space Station p 132 N88-19934
REMBOLD, U.
Mobile robot activity model for autonomous free flying platforms p 82 N88-19507
REMINGTON, ROGER
Cooperative human-machine fault diagnosis p 85 A88-21658
REUMONT, MAURICE R.
Assessment of external contamination for Space Station scientific payloads
[SAE PAPER 871478] p 130 A88-21131
REUTER, JAMES L.
A computer aided engineering tool for ECLS systems
[SAE PAPER 871423] p 98 A88-21087
Intermodule ventilation studies for the Space Station
[SAE PAPER 871428] p 130 A88-21091
REW, DONG-WON
New feedback design methodologies for large space structures: A multi-criterion optimization approach p 59 N88-12535
REYNOLDS, JAMES C.
Task-level robot programming: Integral part of evolution from teleoperation to autonomy p 91 N88-17279
RHOADES, DON
Telerobotic controller development p 89 N88-16370
RIBEIRO, JOSE F.
Simulation and tests of a satellite attitude and orbit control system. General considerations concerning an example case (INPE) and design of a servo rate table
[INPE-4282-PRE/1154] p 62 N88-19572
RICE, S. C.
Emulating a flexible space structure: Modeling
[NASA-TM-100320] p 30 N88-16812
RICE, WILLIAM E.
United States Space Station technical and programmatic interfaces
[IAF PAPER 87-65] p 162 A88-15844
RICHARDSON, K.
KBS V and V as related to automation of space station subsystems: Rationale for a KBS lifecycle p 9 N88-16375
RICHOILLEY, G.
Antibiotic activity in space, results and hypotheses p 159 N88-19952
RICHTER, STEPHEN
A homotopy algorithm for solving the optimal projection equations for fixed-order dynamic compensation - Existence, convergence and global optimality p 16 A88-27401
RIEDEL, U.
Long-term evolution toward European manned spaceflight
[IAF PAPER 87-79] p 136 A88-15853
RIEDEL, UWE
Study on long term evolution towards European manned space flight. Volume 1: Executive summary
[MBB-RA3-004/87-VOL-1] p 147 N88-17689
RIEGER, HERMANN
ERM, the deployable mast for Columbus p 11 A88-15278
RIEL, FRANK J.
Advanced materials technology '87, Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr 6-9, 1987 p 1 A88-13126
RIETMEIJER, FRANS
Astrophysics and the solar nebula p 119 N88-15355
RING, JEFF
Pinhole occulter experiment
[NASA-CR-179206] p 116 N88-11481
RIUMIN, V. V.
Problem of control arisen during the implementation of scientific research program onboard the multipurpose orbital stations
[IAF PAPER 87-105] p 48 A88-15874
ROBERTS, RAYMOND
The United States Space Station revised baseline
[IAF PAPER 87-81] p 162 A88-15855
ROBERTSHAW, H. H.
Dynamics and control of a planar truss actuator p 55 A88-31564
ROBERTSON, BRENT P.
Space Station attitude control momentum requirements
[AIAA PAPER 88-0672] p 51 A88-22502
ROBINSON, JUDITH L.
Crew factors in the design of the Space Station p 151 A88-10947
ROBINSON, MICHAEL J.
Fabrication and assembly of an advanced composite Space Station tetratruss cell p 11 A88-13189
ROCCA, G.
Applicability of A.I. techniques to the Space Station, a study case - Development of an expert system for on board fault management
[IAF PAPER 87-30] p 83 A88-15822
ROCHA, CARLOS
Space station architectural elements model study. Space station human factors research review p 102 N88-19884
ROCHA, R.
Active vibration control in microgravity environment p 55 A88-31565
RODRIGUEZ, G.
Space telerobotics technology demonstration program
[AAS PAPER 87-045] p 84 A88-17000
RODRIGUEZBOSCOSO, J.
Development of a coupled expert system for the spacecraft attitude control problem p 81 N88-17223
ROGERS, JOHN F.
Access flight hardware design and development p 26 N88-10873
ROGERS, JON G.
OMV man/system simulation integration: A preliminary analysis and recommendation
[NASA-CR-182602] p 151 N88-20005
ROGERS, L.
The role of damping in vibration and noise control; Proceedings of the Eleventh Biennial Conference on Mechanical Vibration and Noise, Boston, MA, Sept. 27-30, 1987 p 20 A88-31573
ROGERS, R. C.
Angular momentum management for LEO platforms
[IAF PAPER 87-349] p 49 A88-16039
ROGOWSKI, ROBERT S.
An amplitude modulated laser system for distance and displacement measurement p 47 A88-12813
ROLFE, E. J.
Proceedings of the 1st European In-Orbit Operations Technology Symposium
[ESA-SP-272] p 129 N88-19484
RONCIN, A.
Cardiovascular adaptation to zero-g, during a long term flight (237 days) on board the Salyut 7 Soviet space station (1984) p 158 N88-19920
Cardiac and peripheral circulation assessment by ultrasound on 3 astronauts during two 7-day space flights (1982 Salyut-7 - 1985 STS 51G) p 158 N88-19921
RONDINELLI, G.
Study of mobile communications payload for Columbus Polar Platforms
[ITS-TR-056A/86] p 78 N88-10220
ROSALES, L. A.
Contamination control concepts for space station customer servicing p 131 N88-10860
ROSCHKE, E. J.
Solar dynamic heat receiver thermal characteristics in low earth orbit
[AIAA PAPER 88-0472] p 71 A88-22348
ROSE, L.
Space station integrated propulsion and fluid system study: Fluid systems configuration databook
[NASA-CR-179215] p 79 N88-11753
ROSEN, ROBERT
Pathfinder technologies for bold new missions
[IAF PAPER 87-46] p 1 A88-15832
ROSENFIELD, W. B.
An orbiting control station for free-flying teleoperators - Preliminary design methodology p 51 A88-21647
ROSENTHAL, BRUCE N.
Research opportunities in microgravity science and applications during Shuttle hiatus p 109 A88-13164
ROSS, JERRY L.
Astronaut/EVA construction of Space Station
[AIAA PAPER 88-2459] p 125 A88-31382
ROSSITTO, F.
Preparation of Space Station/Columbus utilization
[IAF PAPER 87-95] p 137 A88-15866
Columbus utilization preparation - Status of ongoing studies p 141 A88-21585
ROSTON, GERALD
A technique to aid in the design of optimal robots for use in space applications p 95 A88-21648
ROUGERON, M.
One mission on board the MIR Space Station - The French-Soviet project Aragatz
[IAF PAPER 87-96] p 137 A88-15867
ROURIS, SUSAN L.
High thermal-transport capacity heat pipes for space radiators
[SAE PAPER 871508] p 35 A88-21155
ROWELL, LARRY F.
Spacecraft Systems Working Group report p 165 N88-10091
ROWELL, LAWRENCE F.
Simulation and control of a Space Station air revitalization system
[SAE PAPER 871425] p 7 A88-21089
Techniques for assessment of flexible space structure control performance
[AIAA PAPER 88-0677] p 52 A88-22507
RUDEY, R.
The evolution of space power systems technology
[IAF PAPER 87-226] p 68 A88-15952
RUDLAND, R. S.
Space station onboard propulsion system: Technology study
[NASA-CR-179233] p 80 N88-15006
RUNDUS, D.
NASA Systems Autonomy Demonstration Program - A step toward Space Station automation p 94 A88-21639
RUPP, CHARLES C.
Tether Dynamics Simulation Workshop summary
[AIAA PAPER 88-0531] p 113 A88-22397
RUSSELL, B. DON
Incipient fault detection and power system protection for spaceborne systems p 66 A88-11826

245

RUSSELL, J. M., III
SAFIRE - A novel high resolution cooled spectrometer for atmospheric research
[IAF PAPER 87-137] p 109 A88-15894
RUSSELL, P.
Communications satellite systems operations with the space station. Volume 3: Supplementary technical report
[NASA-CR-180875] p 77 N88-16794
RUSSELL, ROBERT
Semiautonomous control for satellite servicing
[AIAA PAPER 87-2952] p 81 A88-12573
RUSSELL, ROBERT L.
Video-based satellite attitude determination
p 51 A88-21657
RUTLEDGE, SHARON K.
Oxidation and protection of fiberglass-epoxy composite masts for photovoltaic arrays in the low Earth orbital environment
[NASA-TM-100839] p 97 N88-19734
Mast material test program (MAMATEP)
[NASA-TM-100621] p 31 N88-19592
RYAN, L. E.
Contamination control concepts for space station customer servicing p 131 N88-10960
RYSAVY, GORDON
Transitioning from Space Shuttle to Space Station on-orbit servicing p 121 A88-15290
Customer concerns regarding satellite servicing
p 128 N88-19503

S

SACKHEIM, ROBERT L.
Orbital Maneuvering Vehicle (OMV) propulsion subsystem
[IAF PAPER 87-261] p 149 A88-15976
SACKSTEDER, KURT R.
Microgravity combustion fundamentals
p 79 N88-12529
SADIN, STANLEY R.
Pathfinder technologies for bold new missions
[IAF PAPER 87-46] p 1 A88-15832
SADLER, GERALD G.
Simulation test beds for the space station electrical power system
[NASA-TM-100796] p 74 N88-17715
SAINCT, H.
Metallurgy laboratory for Columbus, executive summary
[SNIAS-813-CA/TS] p 145 N88-10980
SAITO, HIROBUMI
Scanning laser radar system for rendezvous and docking in space
[IAF PAPER 87-53] p 48 A88-15838
SAITO, HISASHI
Two-dimensionally deployable 'SHDF' truss
[IAF PAPER 87-319] p 12 A88-16017
SAITO, M.
JEM present project status
[IAF PAPER 87-63] p 135 A88-15842
Automation and robotics technology application to JEM
[IAF PAPER 87-74] p 136 A88-15849
SAITO, N.
JEM present project status
[IAF PAPER 87-63] p 135 A88-15842
SAKAMAKI, MASAMORI
Research and development of the tension truss antenna
[IAF PAPER 87-317] p 12 A88-16015
SALEHI, S. V.
Application of adaptive observers to the control of flexible spacecraft p 50 A88-16296
SALISBURY, FRANK B.
Space farming in the 21st century
p 106 A88-29237
SAMEL, A.
Implications of shiftwork in space for human physiology experiments p 129 N88-19942
SANBORN, JAMES A.
Development of composite facets for the surface of a space-based solar dynamic concentrator
p 70 A88-18230
SANTY, PATRICIA A.
Psychiatric components of a Health Maintenance Facility (HMF) on Space Station p 153 A88-20864
SANZ, A.
A preliminary study of a fluid science laboratory for space station (Columbus). Part 4: Executive summary
[NLR-TR-87023-L/PT-4] p 79 N88-11072
SARYCHEV, V. A.
The passive attitude motion of the orbital stations Salyut-6 and Salyut-7
[IAF PAPER 87-355] p 49 A88-16045
SASAKI, S.
Results from a series of tethered rocket experiments
p 111 A88-18634
SATOH, S.
Experimental study for carbon dioxide removal system in Space Station
[SAE PAPER 871518] p 43 A88-21161
An experimental study of the Bosch and the Sabatier CO2 reduction processes
[SAE PAPER 871517] p 43 A88-21162
SAUER, RICHARD L.
Review of water disinfection techniques
[SAE PAPER 871488] p 42 A88-21142
Medical effects of ozone disinfection products in spacecraft water
[SAE PAPER 871490] p 154 A88-21144
Treatment bed microbiological control
[SAE PAPER 871492] p 42 A88-21146
Test results of a shower water recovery system
[SAE PAPER 871512] p 42 A88-21158
SAVOV, E. P.
Electrostatic analyzers design for space investigation
p 131 A88-29623
SAWADA, I.
Vapor compression distiller and membrane technology for water revitalization p 39 A88-17072
SAWADA, T.
An experimental study of the Bosch and the Sabatier CO2 reduction processes
[SAE PAPER 871517] p 43 A88-21162
SAWDON, F. E.
The Columbus polar platform p 140 A88-21558
SAWYER, F. G.
Study of a payload for Columbus Polar Platform Earth observation demonstration mission, executive summary
[ESA-CR(P)-2412] p 116 N88-10079
SAX, HARTMUT
Planning framework for high-technology space flight (OHR) p 142 A88-23516
SAZONOV, V. V.
The passive attitude motion of the orbital stations Salyut-6 and Salyut-7
[IAF PAPER 87-355] p 49 A88-16045
SCHAFFER, J.
Development of a coupled expert system for the spacecraft attitude control problem p 61 N88-17223
SCHAFFER, SCOTT E.
Torturing recursive parameter identification algorithms with a gap nonlinearity
[AIAA PAPER 88-2439] p 24 A88-32356
SCHAFHAUSER, E.
Columbus Simulation Facility (CSF)
p 149 N88-19522
SCHENKER, P. S.
Space telerobotics technology demonstration program
[AAS PAPER 87-045] p 84 A88-17000
The NASA telerobot technology demonstrator
p 85 A88-21651
SCHIELOW, N.
EUREX D: An expert system for failure diagnosis and recovery in the TCS of the European retrievable carrier EURECA p 146 N88-16385
SCHLEINITZ, J. P.
Solar-thermal OTVs in comparison with electrical and chemical propulsion systems
[IAF PAPER 87-199] p 77 A88-15936
SCHMERLING, ERWIN
Science on the Space Station: The opportunity and the challenge - A NASA view
[IAF PAPER 87-92] p 98 A88-15863
SCHMID
Development of the Extendable and Retractable Mast (ERM). Design phase 2. Volume 1
[RP-2010-0000-DS/09] p 31 N88-18750
SCHMIDT, E.
Man tended free flyer interior equipment for manned and automated operation
[IAF PAPER 87-75] p 136 A88-15850
SCHMIDT, H. P.
Microgravity research and user support in the Space Station era - The Microgravity User Support Center
[IAF PAPER 87-390] p 110 A88-16061
SCHMIT, L. A.
Control-augmented structural synthesis
[AIAA PAPER 88-1014] p 55 A88-28043
SCHMITT, W.
Study of large solar arrays (SOLA), phase 2A
[BAE-SS/1109] p 74 N88-17106
SCHNEIDER, S. J.
A life test of a 22-Newton (5-lbf) hydrazine rocket
[NASA-TM-100232] p 79 N88-11750
SCHNEIDER, STEVEN J.
Space Station propulsion system technology
p 79 A88-21255
SCHNEPP, TERI
Bioisolation on the Space Station - Of mice and men
[SAE PAPER 871457] p 153 A88-21116
SCHODER, ROBERT
Kinetic isolation tether experiment
[NASA-CR-182456] p 120 N88-16810
SCHOEN, ERHARD
The protein crystallization facility (PCF) for Eureca
[IAF PAPER 87-412] p 110 A88-16082
SCHONBERG, WILLIAM P.
Analysis of oblique hypervelocity impact phenomena
[AIAA PAPER 88-2370] p 23 A88-32307
SCHOONOVER, M. W.
Catalytic processes for space station waste conversion
[NASA-CR-177423] p 44 N88-10491
SCHOTT, J. U.
Radiation problems with the Space Station scenario and the necessary surveillance for astronauts
[IAF PAPER 87-542] p 129 A88-16160
SCHREINER, K. E.
Control considerations for high frequency, resonant, power processing equipment used in large systems
p 67 A88-11829
SCHUBER, ...
Support of life science research in space by the DFVLR Microgravity User Support Center (MUSC)
[IAF PAPER 87-544] p 152 A88-16162
Microgravity User Support Center (MUSC) for EURECA, Spacelab and Columbus missions p 149 N88-19947
SCHULTZ, JOHN R.
Spacecraft water system disinfection technology - Past, present, and future needs
[SAE PAPER 871487] p 41 A88-21141
SCHULZE, M.
Definition and economic evaluation of Space Solar Power Systems (SSPS), part 1
[ILR-MITT-184-1(1987)] p 73 N88-16189
Definition and economic evaluation of Space Solar Power Systems (SSPS), part 2
[ILR-MITT-184-2(1987)] p 73 N88-16190
SCHUNK, RICHARD G.
Environmental control and life support testing at the Marshall Space Flight Center
[SAE PAPER 871453] p 40 A88-21113
SCHUR, ANNE
Impact of intelligent systems on Space Station man-machine interface (MMI) design p 85 A88-21655
SCHUSTER, G. L.
Preliminary conceptual design and weight of a one-megawatt space-based laser power station utilizing a solar-pumped iodine lasant p 65 A88-11816
SCHUSTER, J. R.
Large capacity cryopropellant orbital storage facility
p 60 N88-15932
SCHWARTZ, DEBORAH E.
Microgravity Particle Research on the Space Station
[NASA-CP-2496] p 118 N88-15354
SCHWARTZ, MARY R.
MTK: An AI tool for model-based reasoning
p 9 N88-16372
SCHWEPPE, FRED
Autonomous management of the Space Station electric energy system p 71 A88-21641
SCOTT, A. D., JR.
Design and assembly sequence analysis of option 3 for CETF reference space station
[NASA-TM-100503] p 126 N88-13369
SEARCY, JIM
Life sciences biomedical research planning for Space Station
[SAE PAPER 871484] p 153 A88-21122
SEDEJ, MELAINE
Environmental control and life support system requirements and technology needs for advanced manned space missions
[SAE PAPER 871433] p 39 A88-21096
SEIBERT, G.
Life sciences in the framework of the ESA microgravity program and future flight opportunities
p 148 N88-19895
SEIFERT, FRANK
The protein crystallization facility (PCF) for Eureca
[IAF PAPER 87-412] p 110 A88-16082
SEISER, K. M.
A model for enveloping Space Station logistics requirements p 102 A88-15286
Experiments to ensure Space Station fire safety - A challenge
[AIAA PAPER 88-0640] p 155 A88-22405
SEKIMOTO, S.
Modal damping measurement of MOS-1 Solar Array Paddle p 13 A88-16292
SELTZER, S. M.
Design-to-performance p 2 A88-16295

Cost effective development of a national test bed
[NASA-TM-100321] p 31 N88-19585
SEMENOV, IU. P.
The beginning of the Mir station active operation
[IAF PAPER 87-84] p 136 A88-15858
SENA, J. T.
Integrated heat pipe-thermal storage system performance evaluation p 32 A88-11803
SERENTSCHY, G.
Solar plant growth facility (SPGF) - An approach toward future biological life support systems
p 155 A88-29141
SESHAN, P. K.
Design concepts for bioreactors in space
p 45 N88-17179
SEVERIN, G. I.
Crewman rescue equipment in manned space missions - Aspects of application
[IAF PAPER 87-576] p 153 A88-16187
SGUBINI, S.
Analytical interactive approach for phenomena involving structures, thermal and control aspects. Volume 1: Theory
[ESA-CR(P)-2503-VOL-1] p 60 N88-16803
Analytical interactive approach for phenomena involving structures, thermal, and control aspects. Volume 2: Toward the solution
[ESA-CR(P)-2503-VOL-2] p 60 N88-16804
Analytical interactive approach for phenomena involving structures, thermal, and control aspects. Volume 3: Executive summary
[ESA-CR(P)-2503-VOL-3] p 60 N88-16805
SHABANA, A. A.
Application of perturbation techniques to flexible multibody system dynamics p 14 A88-20908
SHAOHUA, YU
Adaptive control of Large Space Structure (LSS)
[ISAS-R-621] p 58 N88-11740
SHAPLAND, D. J.
The Columbus program, an overview
p 146 N88-16784
SHARPE, J. E. E.
Covariant control of bilateral servos for in-orbit manipulation p 62 N88-19520
SHARPE, MITCHELL R.
Project Horizon - An early study of a lunar outpost
[IAF PAPER 87-659] p 105 A88-16237
SHELLEY, CARL S.
International Space Station operations: New dimensions - October 13, 1987
[IAF PAPER 87-13] p 122 A88-15810
Space Station Program implications from the viewpoint of the Space Station Operations Task Force
[IAF PAPER 87-62] p 123 A88-15856
SHELTON, R. M.
The Columbus polar platform p 140 A88-21558
SHEPARD, G. DUDLEY
Efficient placement of structural dynamics sensors on the space station
[NASA-CR-172015] p 25 N88-10103
SHEPPARD, J. S.
Teleoperation and control study
[BAE-TP-8268] p 87 N88-10489
A teleoperated manipulator system concept for unmanned platforms p 94 N88-19537
SHEREMETYEVSKIY, N.
Gyrostabilizer system of Kvant module
p 60 N88-16099
SHERIDAN, PHILIP L.
Telerobotic truss assembly p 91 N88-17272
SHESKIN, THEODORE J.
Allocating energy to experiments on the Space Station
p 66 A88-11829
SHIFRIN, CAROLE A.
NASA to evaluate two suit designs for Space Station
p 155 A88-24101
SHIH, CHOON-FOO
Verification of large beam-type space structures
p 14 A88-18637
SHILOV, V. M.
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment
p 145 N88-12917
SHIM, JAE-SOO
The component-mode method in a parallel computer environment
[AIAA PAPER 88-2438] p 9 A88-32355
SHIPLEY, J. W.
Development of the Mast Flight System linear dc motor inertial actuator
[AAS PAPER 87-021] p 13 A88-16990
SHIRAKI, K.
Automation and robotics technology application to JEM
[IAF PAPER 87-74] p 136 A88-15849
Environmental control and life support system for Japanese Experiment Module
[SAE PAPER 871429] p 39 A88-21092
SHULZHENKO, E. B.
Man in space flight
[IAF PAPER 87-527] p 162 A88-16150
SHULL, THOMAS A.
Spaceborne optical disk controller development
p 98 A88-12755
NASA spaceborne optical disk recorder development
p 100 A88-29820
SHYKOFF, BARBARA E.
A model-free method for mass spectrometer response correction p 111 A88-19883
SIBERT, L.
Toluene stability Space Station Rankine power system
p 63 A88-11794
SIEMANN, H.
Man tended free flyer interior equipment for manned and automated operation
[IAF PAPER 87-75] p 136 A88-15850
SIEMERS, P. M., III
The Aeroassist Flight Experiment
[IAF PAPER 87-197] p 2 A88-15834
SIEMERS, PAUL M.
Low density aerothermodynamics studies performed by means of the tethered satellite system
p 111 A88-16859
Downward-deployed tethered platforms for high enthalpy aerothermodynamic research
[AIAA PAPER 88-0668] p 114 A88-22514
SILBERBERG, REIN
Radiation hazards on space missions
p 130 A88-22919
SILVER, ROY
AF cryogenic and fluid management spacecraft technology program p 80 N88-15925
SIMAN-TOV, MOSHE
Optimization and analysis of lithium hydride thermal energy storage device configurations for space power applications p 64 A88-11802
SIMU, E.
Dynamic characterization of structures by pulse probing and deconvolution
[AIAA PAPER 88-2230] p 21 A88-32193
SIMPSON, C.
Dynamics of earth-orbiting flexible satellites with multibody components p 52 A88-22609
SIMON, W.
A knowledge-based approach for sensory-controlled assembly operations p 129 N88-19506
SIMONIS, J. C.
The role of damping in vibration and noise control; Proceedings of the Eleventh Biennial Conference on Mechanical Vibration and Noise, Boston, MA, Sept. 27-30, 1987 p 20 A88-31573
SIMPSON, RANDY F.
Explorer Platform
[AIAA PAPER 88-0066] p 112 A88-22046
SIMS, A. J.
Environmental constraints for Polar Platform design
[IAF PAPER 87-09] p 108 A88-15809
SINGH, C.
Reliability models for Space Station power system
p 65 A88-11815
SINGH, R.
Approaches and possible improvements in the area of multibody dynamics modeling
[NASA-CR-179227] p 26 N88-14067
SINGH, SAHJENDRA N.
Attitude control of a three rotor gyrostat in the presence of uncertainty p 52 A88-22933
Flexible spacecraft maneuver - Inverse attitude control and modal stabilization p 53 A88-24281
Three axis rotational maneuver and vibration stabilization of elastic spacecraft p 54 A88-27364
SIRAZETDINOV, TALGAT KASIMOVICH
Theoretical principles of the optimal control of flexible spacecraft p 47 A88-10050
SIROTA, A. R.
The NASA telerobot technology demonstrator
p 85 A88-21851
SIVA, K. V.
Covariant control of bilateral servos for in-orbit manipulation p 62 N88-19520
SKELTON, R. E.
Sensor and actuator selection for optimal closed-loop performance in the presence of correlated noise
p 54 A88-27387
Convergence properties of modal costs for certain distributed parameter systems p 20 A88-31570
SKEPNER, BRAD
Low-cost prototypes for human factors evaluation of Space Station crew equipment
[IAF PAPER 87-553] p 152 A88-16170
SKOOG, A. I.
Progress in European CELSS activities
p 44 N88-12252
SKOU, N.
Study of a payload for Columbus Polar Platform Earth observation demonstration mission, executive summary
[ESA-CR(P)-2412] p 116 N88-10579
SLACHMUYLDERS, E. J.
The use of advanced materials in space structure applications
[IAF PAPER 87-305] p 94 A88-16006
SLAVIN, T.
Controlled Ecological Life Support Systems (CELSS) physiochemical waste management systems evaluation
[NASA-CR-177422] p 45 N88-14626
SLAVIN, T. J.
Lighting considerations in a controlled environmental life support system
[SAE PAPER 871435] p 39 A88-21096
SLEMP, W. S.
Response of composite materials to the Space Station orbit environment
[AIAA PAPER 88-2476] p 95 A88-31390
SLIWA, NANCY E.
Telerobotic research at NASA Langley Research Center p 91 N88-17269
SLOAN, WILLIAM
Space Station ground data management system
p 98 A88-15282
SLOGGET, DAVID
Damming the data stream from space
p 98 A88-19469
SLOGGETT, D. R.
Robots - Autonomous space workers
p 84 A88-15866
SMALL, JOHN W.
Recent developments in water quality monitoring for Space Station reclaimed wastewaters
[SAE PAPER 871447] p 40 A88-21107
SMISTAD, OLAV
Industrial Space Facility
[AIAA PAPER 88-0649] p 3 A88-22484
SMITH, ALVIN
Investigation of design concepts for large space structures to support military applications
[AD-A186098] p 29 N88-15000
SMITH, M. D.
Rapid toxicity detection in water quality control utilizing automated multispecies biomonitoring for permanent space stations p 44 N88-10848
SMITH, MARTHA A.
An operations concept for the Space Station based Astrometric Telescope Facility
[AIAA PAPER 88-0447] p 113 A88-22333
SMITH, SUZANNE WEAVER
Damage detection and location in large space trusses
[AIAA PAPER 88-2481] p 19 A88-31384
SO, KENNETH T.
Environmental control and life support systems analysis for a Space Station life sciences animal experiment
[SAE PAPER 871417] p 39 A88-21081
G189 computer program modeling of environmental control and life support systems for the Space Station
[SAE PAPER 871427] p 39 A88-21090
Design and assembly sequence analysis of option 3 for CETF reference space station
[NASA-TM-100503] p 126 N88-13369
SOBECK, CHARLES K.
Performance considerations for the astrometric telescope facility on the phase 1 space station
[NASA-TM-100040] p 45 N88-14898
SOCK, R.
Columbus preparatory program: Payload element study on a technology demonstration mission, executive summary
[CS-RP-AI-018] p 145 N88-10080
SOEFFKER, E.
Study on long term evolution towards European manned space flight. Volume 1: Executive summary
[MBB-RA3-004/87-VOL-1] p 147 N88-17089
SOERENSEN, B.
Expert system study for spacecraft management
[TL-2699-ISS-1] p 101 N88-15004
SOKOLOVSKII, S. V.
Reconstruction of the vertical atmospheric temperature profile on the basis of refraction measurements from the Salyut-7 orbital station p 131 A88-23930
SOLOV'EV, V. A.
Man in space
[IAF PAPER 87-77] p 162 A88-15852
SOMALVICO, M.
EURECA - An expert system for the management of experiments to be performed on a free-flying platform
[IAF PAPER 87-29] p 135 A88-15821

SOMMER, J.
Rendezvous and docking technology for future European missions p 48 A88-15280
SOMMER, K.
Eureca - European user-friendly retrievable carrier p 139 A88-21251
SOTTA, J. P.
Study of fault tolerant techniques for satellite data handling
[FTT/REP/0001/SAAB] p 101 N88-13860
SOUZA, KENNETH A.
The opportunities for space biology research on the Space Station p 153 A88-20282
The opportunities for space biology research on the Space Station p 155 A88-29134
SOVEY, JAMES S.
Water-propellant resistojets for man-tended platforms
[IAF PAPER 87-259] p 78 A88-15975
Space Station propulsion system technology p 78 A88-21255
Space station propulsion
[NASA-TM-100216] p 79 N88-11746
SPANGLER, L. H.
High intensity 5 eV O-atom exposure facility for material degradation studies p 96 N88-10847
SPECHT
Development of the Extendable and Retractable Mast (ERM). Design phase 2. Volume 1
[RP-2010-0000-DS/09] p 31 N88-18750
SPENCE, RODNEY L.
An allotment planning concept and related computer software for planning the fixed satellite service at the 1988 space WARC
[NASA-TM-100244] p 165 N88-11944
SPENCER, JOHN
Space station architectural elements model study. Space station human factors research review p 102 N88-19884
SPERANS, JOEL
Performance considerations for the astrometric telescope facility on the phase 1 space station
[NASA-TM-100040] p 45 N88-14898
SPEYER, JASON L.
A parameter robust LQG design synthesis with applications to control of flexible structures p 15 A88-27319
SPRING, SHERWOOD C.
Astronaut/EVA construction of Space Station
[AIAA PAPER 88-2459] p 125 A88-31382
SPRINGER, T.
Optical measurements pertaining to Space Station solar dynamic power systems
[IAF PAPER 87-229] p 69 A88-15954
SPUTEK, K.
Definition and economic evaluation of Space Solar Power Systems (SSPS), part 1
[ILR-MITT-184-1(1987)] p 73 N88-16189
Definition and economic evaluation of Space Solar Power Systems (SSPS), part 2
[ILR-MITT-184-2(1987)] p 73 N88-16190
SQUIRE, BERNADETTE
Development of a thermal control coating for space suits
[SAE PAPER 871474] p 34 A88-21129
SQUIRES, R. KENNETH
Downward-deployed tethered platforms for high enthalpy aerothermodynamic research
[AIAA PAPER 88-0688] p 114 A88-22514
SOUYRES, STEVEN W.
Microgravity Particle Research on the Space Station
[NASA-CP-2486] p 118 N88-15354
STACHNIK, R. V.
A test-bed for space interferometry. Space Platform Interferometer (SPI) p 5 N88-10640
STADSNES, J.
AURO: A proposal for flying auroral imaging observatory on the Polar Platform in the Space Station/Columbus program p 119 N88-16268
STANFORD, J.
Overview of crew member energy expenditure during Shuttle Flight 61-B EASE/ACCESS task performance p 156 N88-10882
STANKUNAS, THU P.
Spacecraft solar array substrate development p 68 A88-13187
STARKS, S. A.
NASA Systems Autonomy Demonstration Program - A step toward Space Station automation p 84 A88-21639
STECHER, JOSEPH L., III
Fourteenth Space Simulation Conference: Testing for a Permanent Presence in Space
[NASA-CP-2446] p 5 N88-10829
STEINCAMP, JAMES W.
An advanced imaging space telescope concept
[IAF PAPER 87-460] p 110 A88-16113
STEINSIEK, F.
Study on long term evolution towards European manned space flight. Volume 1: Executive summary
[MBB-RA3-004/87-VOL-1] p 147 N88-17689
STELLA, PAUL
Advanced photovoltaic solar array design p 63 A88-11793
STENNE
Development of the Extendable and Retractable Mast (ERM). Design phase 2. Volume 1
[RP-2010-0000-DS/09] p 31 N88-18750
STEPHENS, JOHN
Astrophysics and the solar nebula p 118 N88-15355
STEPHENSON, L. D.
State-of-the-art technologies for construction in space: A review
[AD-A188412] p 31 N88-19483
STERN, P. H.
Space Station probability of no penetration due to meteoroid and orbital debris impact
[AIAA PAPER 88-2464] p 18 A88-31387
Space station integrated wall design and penetration damage control
[NASA-CR-179169] p 25 N88-10070
STERN, PAUL H.
Hypervelocity impact damage assessment for Space Station
[AIAA PAPER 88-2465] p 18 A88-31388
Space Station pressure wall repair techniques
[AIAA PAPER 88-2469] p 19 A88-31397
STEVENS, N. JOHN
Modeling of environmentally-induced effects within satellites. Part 1: NASCAP modeling of satellites p 58 N88-11721
STEWART, DAVID A.
Thermal response of integral multicomponent composites to a high-energy aerothermodynamic heating environment with surface temperature to 1800 K p 10 A88-12591
STEWART, WILLIAM N.
The GSFC Flight Support System for on-orbit satellite servicing
[AIAA PAPER 88-0448] p 124 A88-22334
STOCKTON, T.
Preliminary analysis of an integrated logistics system for OSSA payloads
[NASA-CR-4114] p 6 N88-19477
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 1: Executive summary p 6 N88-19478
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 2: OSSA integrated logistics support strategy p 6 N88-19479
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 3: OSSA integrated logistics support planning document p 6 N88-19480
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 4: Supportability analysis of the 1.8m centrifuge p 6 N88-19481
STOCKWELL, ALAN E.
An application of MSC/NASTRAN in the interdisciplinary analysis of large space-based structures p 17 A88-29919
STOEWER, H.
Future in-orbit technology demonstrations p 14 A88-21521
STOFAN, ANDREW J.
Preparing for the future p 159 A88-10366
A research laboratory in space
[IAF PAPER 87-60] p 161 A88-15840
STOLTE, H.-H.
Study on long term evolution towards European manned space flight. Volume 1: Executive summary
[MBB-RA3-004/87-VOL-1] p 147 N88-17689
STONE, R. W.
Analysis of a rotating advanced-technology space station for the year 2025
[NASA-CR-178345] p 107 N88-19580
STORAASLI, OLAF
Solution of structural analysis problems on a parallel computer
[AIAA PAPER 88-2267] p 22 A88-32240
Three parallel computation methods for structural vibration analysis
[AIAA PAPER 88-2391] p 24 A88-32323
STOREY, OWEN
Report from the MPP Working Group to the NASA Associate Administrator for Space Science and Applications
[NASA-TM-87819] p 100 N88-11402
STRASSER, RETO J.
A theoretical concept for state changes and shape changes in weightlessness p 157 N88-15365
STRUMPF, HAL J.
Solar receiver for the Space Station Brayton engine
[ASME PAPER 87-GT-252] p 62 A88-11134
STUBBS, NORRIS
Nondestructive construction error detection in large space structures
[AIAA PAPER 88-2460] p 18 A88-31383
STUDER, PHILLIP A.
Attitude Control Working Group report p 57 N88-10099
STUHLINGER, ERNST
Materials processing twin experiment
[AIAA PAPER 88-0348] p 163 A88-22255
SU, RENJENG
Robust controller design for flexible structures
[AD-A187217] p 30 N88-18009
SUDAR, M.
Electrochemically regenerable carbon dioxide/moisture control technology for an Advanced Extravehicular Mobility Unit
[SAE PAPER 871470] p 91 A88-21121
SUOMELER, K. J.
Small reentry vehicles p 150 A88-26364
SUIT, WILLIAM T.
An analysis of the effect of aeroassist maneuvers on orbital transfer vehicle performance
[NASA-TM-89117] p 150 N88-14116
Aeroassisted orbit transfer vehicle trajectory analysis
[NASA-TM-89139] p 62 N88-19575
SUMMERS, THOMAS S.
An optically tethered and controlled satellite system
[IAF PAPER 87-50] p 109 A88-15835
SUN, C. T.
Enhancement of frequency and damping in large space structures with extendable members
[AIAA PAPER 88-2482] p 57 A88-32383
SUNDBERG, GALE R.
LERC power system autonomy program 1990 demonstration p 67 A88-11861
SUNDBERG, R.
The ac power system testbed
[NASA-CR-175068] p 72 N88-11948
SURAUER, M.
Decentralized/hierarchical control for large flexible spacecraft
[MBB-UR-967-87] p 52 A88-23982
SUTTER, THOMAS R.
Dynamics and control characteristics of a reference Space Station configuration
[AIAA PAPER 88-2485] p 55 A88-31394
SVED, J.
A Pallet-based space program for Australia p 122 A88-15521
SVENINGSSON, M.
Study of fault tolerant techniques for satellite data handling
[FTT/REP/0001/SAAB] p 101 N88-13860
SVENNINGSSON, MATS
Central processing unit for fault tolerant computing in Columbus p 139 A88-21254
SVERTSHEK, V. I.
Crewman rescue equipment in manned space missions - Aspects of application
[IAF PAPER 87-576] p 153 A88-16187
SWANSON, HARVEY T.
A model-free method for mass spectrometer response correction p 111 A88-19883
SWENSON, FRANK R.
Tether Elevator Crawler Systems (TECS) p 119 N88-15631
SWITZER, COLLEEN A.
Coaxial tube array space transmission line characterization p 75 A88-11985
SZAKALY, Z.
Computing architecture for telerobots in earth orbit p 99 A88-21650
SZIRMAY, S. Z.
Space telerobotics technology demonstration program
[AAS PAPER 87-045] p 94 A88-17000
SZTIPANOVITS, J.
Automated testing and integration of heterogeneous systems p 93 A88-11874

T

TACINA, ROBERT R.
Space Station propulsion system technology p 78 A88-21255
Space station propulsion
[NASA-TM-100216] p 79 N88-11746
TAFFORIN, C.
Cosmonaut behaviour in orbital flight situation - Preliminary ethological analyses
[IAF PAPER 87-529] p 152 A88-16151

TAHK, MINJEA
A parameter robust LQG design synthesis with applications to control of flexible structures
p 15 A88-27319

TAKAHARA, KENICHI
Vibration control of truss beam structures using axial force actuators
[AIAA PAPER 88-2273] p 22 A88-32229

TAKIZAWA, Y.
Development scenario of H-II Orbiting Plane, HOPE
[IAF PAPER 87-210] p 48 A88-15943

TAMAYO, TAK CHAI
Space station software reliability analysis based on failures observed during testing at the multisystem integration facility p 101 N88-14884

TANNER, STEVE
Prototype resupply scheduler p 9 N89-16429

TANZER, H. J.
Hybrid honeycomb panel heat rejection system
[SAE PAPER 871419] p 34 A88-21083
Advanced radiator concepts utilizing honeycomb panel heat pipes
[NASA-CR-172017] p 37 N88-12747

TARTER, JILL
Physics and chemistry p 119 N88-15359

TATRO, CHARLES A.
Photovoltaic power modules for NASA's manned space station
[NASA-TM-100229] p 72 N88-11745

TAYLOR, BRIAN G.
Report on the scientific satellites of the European Space Agency
[ESA-SP-1080] p 116 N88-10081

TAYLOR, ROY A.
Analysis of oblique hypervelocity impact phenomena
[AIAA PAPER 88-2370] p 23 A88-32307

TAYLOR, THOMAS C.
Spacehab - A manned Space Station testbed
p 103 A88-15287
Spacehab's commercialization of microgravity research activities
[IAF PAPER 87-629] p 110 A88-16221
Space Station habitat and laboratory module rack flight testing in the Spacehab Module
[SAE PAPER 871416] p 103 A88-21080
On-orbit servicing enhancements with Crewlock EVA operations from the Spacehab module
[SAE PAPER 871496] p 124 A88-21148
The Spacehab module passive thermal control
[SAE PAPER 871508] p 35 A88-21154
Space station architectural elements model study Space station human factors research review
p 102 N88-19884

TAYLOR, TOM
Low-cost prototypes for human factors evaluation of Space Station crew equipment
[IAF PAPER 87-553] p 152 A88-16170

TEAGAN, W. P.
Performance characteristics of moving belt radiators
p 33 A88-12006

TEICHMAN, L. A.
Response of composite materials to the Space Station orbit environment
[AIAA PAPER 88-2476] p 95 A88-31390

TELLER, V. B.
Space station structures development
[NASA-CR-179261] p 30 N88-16792

TEMPLE, L. PARKER, III
Department of Defense space policy and the development of a global policy for the control of space debris
[IAF PAPER 87-575] p 129 A88-16166

TEMPLIER, J.
Antibiotic activity in space, results and hypothesis
p 159 N88-19952

TEOH, WILLIAM
Teleoperator and robotics system analysis
[NASA-CR-179220] p 97 N88-12155

TEREN, FRED
Space Station electric power system requirements and design p 63 A88-11792

THARP, H. S.
Structural decomposition approach to design of robust decentralized controllers for large scale systems
p 53 A88-27358

THIEMET, W. F.
The integration of a mesh reflector to a 15-foot box truss structure. Task 3: Box truss analysis and technology development
[NASA-CR-179228] p 91 N88-18941

THIRKETTLE, A. J.
MTFF operational design features
p 134 A88-15296
Columbus: Attached Pressurized Module configuration - MTFF Pressurized Module configuration
p 134 A88-15298
Man Tended Free Flyer configurations and servicing scenarios
[MSB-UR-E-984-87] p 125 A88-23990
Man-Tended Free Flyer operational design features
p 126 N88-19485

THOMPSON, CLIFFORD D.
Environmental control and life support systems analysis for a Space Station life sciences animal experiment
[SAE PAPER 871417] p 39 A88-21081

THOMPSON, R. L.
Structural assessment of a Space Station solar dynamic heat receiver thermal energy storage canister
[AIAA PAPER 88-2487] p 72 A88-31396

THOMPSON, WILLIAM M.
Manipulator arm design for the Extravehicular Teleoperator Assist Robot (ETAR): Applications on the space station p 91 N88-17270

THON, B.
Cosmonaut behaviour in orbital flight situation - Preliminary ethological analysis
[IAF PAPER 87-529] p 152 A88-16151

THORNBRUGH, ALLISON L.
Autonomous spacecraft operations - Problems and solutions
[AIAA PAPER 87-2850] p 81 A88-12571

THORNE, A.
A composite structural system for a large collapsible space antenna p 19 A88-31403

THORNTON, C. A.
Development of a non-phase-change waste-water treatment subsystem
[SAE PAPER 871514] p 43 A88-21159

THORNTON, EARL A.
Self-shadowing effects on the thermal-structural response of orbiting trusses p 32 A88-11734

THORSTENSON, YVONNE R.
Medical effects of iodine disinfection products in spacecraft water
[SAE PAPER 871490] p 154 A88-21144

THOULOUSE, J.
Biomedical payload of the French-Soviet long duration flight
[IAF PAPER 87-541] p 152 A88-16159

TIBALDI, MARCO
Integrated control of large flexible structures
p 16 A88-23474

TILLEY, R.
An AI approach for scheduling space station payloads at Kennedy Space Center p 90 N88-16425

TILTON, D. E.
Fluid loss from a puncture of a space radiator
p 72 A88-30317

TIMASHEV, SERGEI VLADIMIROVICH
Optimization of the energy systems of manned orbital stations - Mathematical modeling and selection of efficient structures p 68 A88-15664

TINKER, M. L.
An investigation of the damping phenomena in wire rope isolators p 21 A88-31597

TIPPS, R. W.
The Space Station air revitalization subsystem design concept
[SAE PAPER 871448] p 40 A88-21108

TISCHLER, V. A.
Simultaneous structural and control optimization via linear quadratic regulator eigenstructure assignment
p 28 N88-13622

TIWARI, S.
Modal coupling of structures with complex storage moduli p 20 A88-31540

TIXADOR, R.
Antibiotic activity in space, results and hypothesis
p 159 N88-19952

TODA, YOSHITSUGU
Development of a master slave manipulator system for space use p 86 A88-26975

TOMASKO, MARTIN
Astrophysics and the solar nebula
p 118 N88-15355
Atmospheric science p 5 N88-15357

TOMPKINS, S. S.
Response of composite materials to the Space Station orbit environment
[AIAA PAPER 88-2476] p 95 A88-31390

TONG, M. T.
Structural assessment of a Space Station solar dynamic heat receiver thermal energy storage canister
[AIAA PAPER 88-2487] p 72 A88-31396

TOON, O. BRIAN
Atmospheric science p 5 N88-15357

TORCZYNER, ROBERT
Structures and Materials Working Group report
p 25 N88-10093

TORIN, J.
Study of fault tolerant techniques for satellite data handling
[FTT/REP/0001/SAAB] p 101 N89-13860

TORVIK, P. J.
Fractional derivatives in the description of damping materials and phenomena p 20 A88-31589

TOUSSAINT, M.
The Resource Module p 140 A88-21559

TRAUB, W. A.
A test-bed for space interferometry: Space Platform Interferometer (SPI) p 5 N88-10640

TRAXLER, G.
Solar plant growth facility (SPGF) - An approach toward future biological life support systems
p 155 A88-29141

TREDWAY, WILLIAM K.
Carbon fiber reinforced glass matrix composites for space based applications
[AD-A194355] p 96 N88-12546

TREMBLAY, PAUL G.
High pressure water electrolysis for the Space Station
[SAE PAPER 871473] p 41 A88-21128

TREVETT, J. W.
Confidentiality of data p 145 N88-12136

TRIVELATO, GILBERTO DAC.
Simulation and tests of a satellite attitude and orbit control system: General considerations concerning an example case (INPE) and design of a servo rate table
[INPE-4282-PRE/1154] p 62 N88-19572

TROMBLEE, JON D.
A dishwasher for the Space Station
[SAE PAPER 871411] p 39 A88-21078

TROUTMAN, P.
The impact of asymmetric physical properties on large space structures
[AIAA PAPER 88-2486] p 19 A88-31395

TRUCCO, R.
Feasibility study of a stabilizer fin for the tethered satellite system p 111 A88-16840

TRUSCOTT, P. R.
Environmental constraints for Polar Platform design
[IAF PAPER 87-09] p 108 A88-15809

TRUSS, P.
Configuration drivers for the European Polar Platform
[IAF PAPER 87-104] p 137 A88-15873

TSAI, FU-SHENG
Computer modeling and simulation of a 20kHz ac distribution system for Space Station p 66 A88-11827

TSAO, C. H.
Radiation hazards on space missions
p 130 A88-22919

TSUCHIYA, KAZUO
Reduced order models of a large flexible spacecraft
[IAF PAPER 87-356] p 13 A88-19048
Formulation of rigid multibody systems in space
p 14 A88-21221
Formulation methods of rigid multibody systems for large space structures and some results of computer simulation
[NAL-TR-942] p 30 N88-17730

TSUCHIYA, MITSUHIRO
NASDA's new test facilities for satellites and rockets
p 147 N88-18951

TUBBS, ELDRED F.
Wavefront error sensing
[NASA-CR-181504] p 76 N88-12030

TULLIS, THOMAS S.
FACILE - A computer program for Space Station facilities layout and activity simulation
[SAE PAPER 871415] p 7 A88-21079

TUOZZI, A.
Study of mobile communications payload for Columbus Polar Platforms
[ITS-TR-056A/86] p 76 N88-10220

TURNER, JAMES D.
Large-angle slewing maneuvers for flexible spacecraft
[NASA-CR-4123] p 60 N88-16060

TURNER, LARRY D.
Preliminary design of the Space Station internal thermal control system
[SAE PAPER 871505] p 35 A88-21151

TURNER, PHILIP R.
Autonomy, automation, and systems
p 85 A88-21640

TUTTEROW, ROBIN D.
Access flight hardware design and development
p 26 N88-10873

TYSON, RICHARD
In-space research, technology and engineering experiments and Space Station p 3 A88-27750

U

UDA, HIROSHI
Development of on-board satellite communications equipment in the Geostationary Platform era
[IAF PAPER 87-495] p 110 A88-16136

ULSCHAK, FRANCIS L.
Crew productivity issues in long-duration space flight
[AIAA PAPER 88-0444] p 154 A88-22330

UNZ, F.
Preparation of Space Station/Columbus utilization
[IAF PAPER 87-95] p 137 A88-15866
Columbus utilization preparation - Status of ongoing studies p 141 A88-21585

V

VACHTSEVANOS, G.
On the hierarchical control of the Space Station common module thermal system p 33 A88-14980

VADALI, S. R.
Feedback control design for smooth, near minimum time rotational maneuvers of flexible spacecraft
[AIAA PAPER 88-0671] p 51 A88-22501

VAHRENWALD, A.
Legal protection of the Polar Platform's users p 145 N88-12135

VAINBERG, D. M.
Development experience of the attitude control system using single-axis control moment gyros for long-term orbiting space stations
[IAF PAPER 87-04] p 48 A88-15804

VALLERANI, E.
A new Italian proposal for a Space Station Assembly and Servicing Vehicle (ASMV)
[IAF PAPER 87-37] p 135 A88-15827
The Spacehab module passive thermal control
[SAE PAPER 871508] p 35 A88-21154

VALLERANI, ERNESTO
Columbus pressurized module p 140 A88-21557

VAN DEN ABEELEN, LUCIEN
Soviet shuttle for Space Station role p 138 A88-18700

VAN GAVER, M.
Challenge '95 - The Ariane 5 Development Programme
[IAF PAPER 87-185] p 137 A88-15926

VAN LEEUWEN, W.
Control aspects of a European space manipulator system p 83 A88-16313

VAN METER, STEVEN D.
Space Station Program threat and vulnerability analysis
[AIAA PAPER 87-3082] p 104 A88-26210

VAN WOERKOM, P. TH. L. M.
Mathematical models of flexible spacecraft dynamics - A survey of order reduction approaches p 13 A88-16293

VANDERPLAATS, G. N.
An efficient multilevel optimization method for engineering design
[AIAA PAPER 88-2226] p 8 A88-32190

VANDERPLOEG, JAMES M.
The role of preventive medicine in the future of USA space life sciences p 155 A88-29104

VANIARKHA, E. S.
Stratospheric luminescence observed from the Salyut-7 station p 144 A88-30076

VANNARONI, G.
Laboratory simulation of the electrodynamic interactions of a tethered satellite with an ionospheric plasma
[IFSI-86-3] p 119 N88-15822

VANNUCCI, RAYMOND D.
Mechanical properties characterization of composite sandwich materials intended for space antenna applications
[NASA-TM-88880] p 25 N88-10121

VANSWIETEN, A. C. M.
The ESA/Fokker service end-effector subsystem. A robotic/man-compatible servicing approach p 92 N88-19502

VANWINNENDAEL, M.
Robotics servicing experiment p 93 N88-19529

VARSI, GIULIO
NASA's Telerobotics R & D Program - Status and future directions
[IAF PAPER 87-24] p 82 A88-15818

VASSAUX, D.
Biomedical payload of the French-Soviet long duration flight
[IAF PAPER 87-541] p 152 A88-16159

VAUGHAN, COURTENAY
Solution of structural analysis problems on a parallel computer
[AIAA PAPER 88-2267] p 22 A88-32240

VEATCH, JOHN D.
Space Station Program threat and vulnerability analysis
[AIAA PAPER 87-3082] p 104 A88-26210

VEDRENNE, M.
Challenge '95 - The Ariane 5 Development Programme
[IAF PAPER 87-185] p 137 A88-15926

VENKAYYA, V. B.
Optimization of actively controlled structures using goal programming techniques p 53 A88-25797
Optimum design of structures with multiple constraints p 16 A88-28042
System identification of flexible structures
[AIAA PAPER 88-2361] p 23 A88-32301
Simultaneous structural and control optimization via linear quadratic regulator eigenstructure assignment p 28 N88-13822

VEREEN, MARY
Third Conference on Artificial Intelligence for Space Applications, part 1
[NASA-CP-2492-Pt-1] p 89 N88-16380

VERESHCHAGIN, V. P.
Development experience of the attitude control system using single-axis control moment gyros for long-term orbiting space stations
[IAF PAPER 87-04] p 48 A88-15804

VEROSTKO, CHARLES E.
Recent developments in water quality monitoring for Space Station reclaimed wastewaters
[SAE PAPER 871447] p 40 A88-21107
Test results of a shower water recovery system
[SAE PAPER 871512] p 42 A88-21158

VEST, CHARLES E.
Materials selection as related to contamination of spacecraft critical surfaces p 95 A88-26965

VIDYASAGAR, A.
Deployment dynamics of accordian type of deployable solar arrays considering flexibility of closed control loops
[IAF PAPER 87-256] p 11 A88-15974

VILLAMIL, ANA M.
EASE/ACCESS ground processing at Kennedy Space Center p 27 N88-10977

VILLMANN, CH.
Observations of ocean and sea bottom relief from space p 143 A88-26099

VINCENT, T. L.
Control for energy dissipation in structures
[AIAA PAPER 88-2272] p 22 A88-32226

VINH, NGUYEN X.
Optimal time free modal transfers between elliptical orbits
[IAF PAPER 87-325] p 78 A88-16021

VINZ, F.
Development of a coupled expert system for the spacecraft attitude control problem p 61 N88-17223

VIRGILIO, GIUSEPPE
Trends to reduce development and operation costs for experiments of the future space laboratory
[IAF PAPER 87-100] p 105 A88-15871

VISENTINE, JAMES
High intensity 5 eV O-atom exposure facility for material degradation studies p 96 N88-10847

VISSER, F. B.
A preliminary study of a fluid science laboratory for space station (Columbus). Part 4: Executive summary
[NLR-TR-87023-L-PT-4] p 79 N88-11072

VITT, ELMAR
The dangers of space debris - New developments and discoveries p 130 A88-18398

VLIMANT, P.
Study of fault tolerant techniques for satellite data handling
[FTT/REP/0001/SAAB] p 101 N88-13860

VOLKOV, A. A.
Reconstruction of the vertical atmospheric temperature profile on the basis of refraction measurements from the Salyut-7 orbital station p 131 A88-23930

VOLZ, RICHARD A.
Translation and execution of distributed Ada programs - Is it still Ada? p 7 A88-21643

VON DER LIPPE, JUERGEN
Enhanced Eureca configuration/operations p 134 A88-15295

VON FLOTOW, A. H.
Experimental component mode synthesis of structures with sloppy joints
[AIAA PAPER 88-2411] p 24 A88-32339

VON FLOTOW, ANDREAS
Active modification of wave reflection and transmission in flexible structures p 16 A88-27395
Torturing recursive parameter identification algorithms with a gap nonlinearity
[AIAA PAPER 88-2439] p 24 A88-32356

VONDRAK, RICHARD R.
Solar power satellites p 70 A88-17023

VOSS, FRED E.
Thermal contact conductance of pressurized surfaces
[AIAA PAPER 88-0467] p 36 A88-22343

VREEBURG, J. P. B.
A preliminary study of a fluid science laboratory for space station (Columbus). Part 4: Executive summary
[NLR-TR-87023-L-PT-4] p 79 N88-11072

VU-QUOC, L.
Dynamics of earth-orbiting flexible satellites with multibody components p 52 A88-22609

VYKUKAL, H.
An innovative exercise method to simulate orbital EVA work - Applications to PLSS automatic controls
[SAE PAPER 871475] p 154 A88-21130

W

WADA, B. K.
Multiple boundary condition test (MBCT) - Identification with mode shapes
[AIAA PAPER 88-2353] p 23 A88-32293

WADA, BEN K.
Passive damping for space truss structures
[AIAA PAPER 88-2469] p 24 A88-32360

WAGNER, H.
Reliability models for Space Station power system p 65 A88-11a15

WAITES, H. B.
Emulating a flexible space structure: Modeling
[NASA-TM-100320] p 30 N88-16812
Cost effective development of a national test bed
[NASA-TM-100321] p 31 N88-19585

WAITES, HENRY
Large space structures testing
[AAS PAPER 87-036] p 13 A88-16996

WAKEFORD, RONALD C.
Project Horizon - An early study of a lunar outpost
[IAF PAPER 87-659] p 105 A88-16237

WALBERG, G. D.
The Aeroassist Flight Experiment
[IAF PAPER 87-197] p 2 A88-15934

WALIGORA, J. W.
Overview of crew member energy expenditure during Shuttle Flight 61-B EASE/ACCESS task performance p 156 N88-10882

WALKER, G. H.
Preliminary conceptual design and weight of a one-megawatt space-based laser power station utilizing a solar-pumped iodine laser p 65 A88-11816

WALKER, GRAHAM
Ross-Stirling engine - A high performance dynamic space power system p 63 A88-11797

WALKER, JAMES D.
An overview of space station operations
[SAE SP-687] p 122 A88-15575

WALLIN, WAYNE E.
Advanced space solar dynamic power systems beyond IOC Space Station p 64 A88-11796

WALLS, BRYAN
Expert system for fault detection and recovery for a space based power management and distribution system p 66 A88-11982

WALSH, RICK
Applications for power control within a Space Station module p 67 A88-11954

WALTON, OTIS
Physics and chemistry p 118 N88-15368

WANG, P. K. C.
Disturbance and vibration isolation in space stations by means of mechanical decoupling p 11 A88-12932

WANG, R. T.
Enhancement of frequency and damping in large space structures with extendable members
[AIAA PAPER 88-2482] p 57 A88-32363

WANG, REN-HONG
Computer-aided modeling and prediction of performance of the modified Lundell class of alternators in space station solar dynamic power systems
[NASA-CR-182538] p 74 N88-19000

WARD, DONALD T.
Aeroassisted orbital transfer vehicle guidance performance in the presence of density dispersions
[AIAA PAPER 88-0302] p 150 A88-22217

WARTENBERG, HEINZ
External payload servicing: Operational requirements and technology p 129 N88-19541

WATANABE, NAOYUKI
Two-dimensionally deployable 'SHOF' truss
[IAF PAPER 87-319] p 12 A88-16017

WATANABE, Y.
Results from a series of tethered rocket experiments p 111 A88-19634

250

WATERMAN, DONALD
Potential applications of expert systems and operations research to space station logistics functions
[NASA-CR-180473] p 87 N88-12342
WATERS, L.
Steady state micro-g environment on Space Station
[AIAA PAPER 88-2462] p 4 A88-31285
WATSON, JUDITH J.
Astronaut/EVA construction of Space Station
[AIAA PAPER 88-2459] p 125 A88-31382
Results of the ACCESS experiment
p 27 N88-10880
WATZIN, JAMES G.
The Flight Telerobotic Servicer (FTS) - A focus for automation and robotics on the Space Station
[IAF PAPER 87-25] p 82 A88-15817
WEBBON, BRUCE
Development of a thermal control coating for space suits
[SAE PAPER 871474] p 34 A88-21129
An innovative exercise method to emulate orbital EVA work - Applications to PLSS automatic controls
[SAE PAPER 871475] p 154 A88-21130
WEBSTER, WILLIAM J., JR.
Applications of tethered satellites to some problems of terrestrial physics
[AIAA PAPER 88-0689] p 114 A88-22515
WECHSLER, D. B.
An approach to design knowledge capture for the space station p 7 A88-21642
Design knowledge capture for the space station
p 9 N88-17239
WEEKS, DAVID J.
LERC power system autonomy program 1990 demonstration p 67 A88-11861
Artificial intelligence and space power systems automation p 89 N88-16381
WEGMANN, H. M.
Implications of shiftwork in space for human physiology experiments p 129 N88-19942
WEIBEL, M.
European EVA requirements and space suit design
[IAF PAPER 87-41] p 152 A88-15830
WEIBEL, MARC
Evolutive concept of an EVA space suit
[SAE PAPER 871519] p 154 A88-21163
WEIDENSCHILLING, STUART
Planetary science p 5 N88-15356
WEIDMAN, DEENE J.
Space station accommodations for lunar base elements - A study
[NASA-TM-100501] p 106 N88-14907
WEIDELT, GERD
ISIS: Imaging Speckle Interferometer in Space
p 116 N88-10625
WEINSTEIN, LINDA
Social factors in space station interiors
p 46 N88-19888
WEISL, JAMES R.
Science on the Space Station: The opportunity and the challenge - A NASA view
[IAF PAPER 87-92] p 98 A88-15863
OSSA's Telescience concept for the Space Station era
[AIAA PAPER 88-0120] p 112 A88-22093
WEISS, MILES
Solar power satellites - Still in the dark
p 70 A88-19002
WEITZ, DAVID
Physics and chemistry p 118 N88-15359
WELCH, JAMES C.
Hubble Space Telescope servicing - Experience base for a new era
[IAF PAPER 87-38] p 109 A88-15829
WERNER, BRAD
Physics and chemistry p 118 N88-15359
WERSTIUK, H.
Assembling, maintaining and servicing Space Station
[IAF PAPER 87-85] p 123 A88-15859
WESSLING, FRANCIS C.
Vapor transport furnace for organic crystals and films
[AIAA PAPER 88-0190] p 113 A88-22113
WETCH, JOSEPH R.
Comparison of high temperature heat rejection concepts to system-related requirements p 33 A88-11809
WETZEL, P.
Utilization of robotics and telepresence for future in-orbit operations p 93 N88-19527
WEYANDT, C.
Communications satellite systems operations with the space station. Volume 3: Supplementary technical report
[NASA-CR-180875] p 77 N88-16784
WEYANDT, CHARLES J.
Economic benefits of the Space Station to commercial communication satellite operators
[IAF PAPER 87-622] p 183 A88-16215
WEYDANDT, JUERGEN
External payload servicing: Operational requirements and technology p 129 N88-19541
WHALEN, MARGARET V.
Compatability of dispersion-strengthened platinum with resistojet propellants
[NASA-TP-2765] p 79 N88-12538
WHITE, NANCY H.
A space transportation system operations model
[NASA-TM-100481] p 9 N88-14999
WHITNEY, CYNTHIA K.
Information prioritization for control and automation of space operations p 86 A88-27355
WHITSETT, C. E.
New tools for EVA operations
[SAE PAPER 871490] p 124 A88-21150
WHITTEN, ROBERT
Atmospheric science p 5 N88-15357
WHITTENBERGER, J. DANIEL
Fluoride salts and container materials for thermal energy storage applications in the temperature range 973 - 1400 K p 32 A88-11804
WHYTE, WAYNE A., JR.
An allotment planning concept and related computer software for planning the fixed satellite service at the 1988 space WARC
[NASA-TM-100244] p 165 N88-11944
WIDJAJA, I.
Rendezvous and docking technology for future European missions p 48 A88-15280
WIELAND, P.
The Space Station air revitalization subsystem design concept
[SAE PAPER 871449] p 60 A88-21108
WIENAND, ST.
A knowledge-based approach for sensory-controlled assembly operations p 128 N88-19506
A comparative survey of mathematical models for dynamic simulation of in-orbit manipulation operations
p 148 N88-19533
WIERENGA, T.
Columbus preparatory program: Payload element study on a technology demonstration mission, executive summary
[CS-RP-AI-016] p 45 N88-10080
WIGGINS, JAMES
Safety philosophy, policy, and requirements for manned spaceflight. Volume 1: Executive summary
[HEG-0886/1036-VOL-1] p 157 N88-15826
WIJKER, J. J.
Thermal structural control modelling techniques
[FOK-TR-R-86-039] p 38 N88-15828
WILBER, GEORGIA A.
Treatment bed microbiological control
[SAE PAPER 871492] p 42 A88-21146
WILEY, LOWELL F.
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 2: Study results, attachment 2: Phase A Conceptual design and programmatics
[NASA-CR-179272] p 46 N88-17722
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 2: Study results, Appendix E: Work breakdown structure and dictionary
[NASA-CR-179274] p 46 N88-17723
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 2: Study results, Appendix D: Life sciences research facility requirements
[NASA-CR-179273] p 46 N88-17724
WILHITE, MICHAEL
Looking to year 2001 p 104 A88-13974
WILLEY, RONALD J.
Raman spectra of adsorbed layers on space shuttle and AOTV thermal protection system surface
p 132 N88-14890
WILLIAMS, D. M.
Traction-drive seven degrees-of-freedom telerobot arm: A concept for manipulation in space
[DE87-010895] p 97 N88-10946
WILLIAMS, FRANK L.
STS propellant scavenging systems study. Part 2, volume 2: Cost and WBS/dictionary
[NASA-CR-179276] p 81 N88-17717
WILLIAMS, JAMES H., JR.
Natural frequencies and structural integrity assessment of large space structures
[AD-A186139] p 29 N88-15001
Wave propagation experiments on 22-bay lattice
[AD-A186140] p 29 N88-15002
WILLIAMS, M. D.
Preliminary conceptual design and weight of a one-megawatt space-based laser power station utilizing a solar-pumped iodine laser p 65 A88-11816
WILLIAMS, PAUL
Optimization and analysis of lithium hydride thermal energy storage device configurations for space power applications p 64 A88-11802
WILLIAMS, R.
Automated testing and integration of heterogeneous systems p 33 A88-11874
WILLIAMS, R. B.
Space Station Information System - Concepts and international issues
[IAF PAPER 87-76] p 98 A88-15851
WILLIS, CHARLES E.
Spacecraft water system disinfection technology - Past, present, and future needs
[SAE PAPER 871467] p 41 A88-21141
WILSON, J. F.
Very high damping in large space structures
p 20 A88-31594
WILSON, JAMES F.
Viscous damped space structure for reduced jitter
p 28 N88-13623
WILSON, MAYWOOD L.
Potential for on-orbit manufacture of large space structures using the pultrusion process
[NASA-TM-4016] p 28 N88-13398
WILSON, R. GARY
A dishwasher for the Space Station
[SAE PAPER 871611] p 38 A88-21076
WILSON, S.
Space station integrated propulsion and fluid system study: Fluid systems configuration databook
[NASA-CR-179215] p 79 N88-11753
WINTER, E.
Study of large solar arrays (SOLA), phase 2A
[BAE-SS/1109] p 74 N88-17106
WISLEZ
Development of the Extendable and Retractable Mast (ERM). Design phase 2: Volume 1
[RP-2010-0000-DS/09] p 51 N88-19750
WITTMANN, K.
Microgravity research and user support in the Space Station era - The Microgravity User Support Center
[IAF PAPER 87-390] p 110 A88-16061
WOLF, HENRY
Downward-deployed tethered platforms for high enthalpy aerothermodynamic research
[AIAA PAPER 88-0688] p 114 A88-22514
WOLF, ROBERT S.
Experimental assembly of structures in EVA: Hardware morphology and development issues p 26 N88-10872
WOLFF, F.
Control considerations for high frequency, resonant, power processing equipment used in large systems
p 47 A88-11829
WOLFSBERGER, W.
Mission profiles of the MTFF co-orbiting with the US Space Station p 6 N88-19487
WOLOSHUN, KEITH A.
An evaluation of heat pipe radiators incorporating pumped liquid return p 33 A88-11810
WONG, C.
KBS V and V as related to automation of space station subsystems: Rationale for a KBS lifecycle
p 9 N88-16375
WONG, CARLA
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems
[NASA-TM-89705] p 98 N89-15497
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems
p 99 N89-16373
WONG, CARLA M.
Monitoring of space station life support systems with miniature mass spectrometry and artificial intelligence
p 40 N88-16376
WONG, JOSEPH
Space Assembly, Maintenance, and Servicing Study (SAMSS) p 105 N88-10089
WOO, HENRY H.
Momentum management and attitude control design for a Space Station p 55 A88-26703
WOOD, GEORGE M.
Downward-deployed tethered platforms for high enthalpy aerothermodynamic research
[AIAA PAPER 88-0688] p 114 A88-22514
WOOD, GEORGE M., JR.
Low density aerothermodynamics studies performed by means of the tethered satellite system
p 111 A88-16859
WOOD, P. J.
A near field test system for very large antennas
p 13 A88-17599
WOOD, PETER C.
Stability of RA-45 solid amine resin as a function of carbon dioxide absorption and steam desorption cycling
[SAE PAPER 871452] p 40 A88-21112

WOODARD, STANLEY E.
The nonlinear behavior of a passive zero-spring-rate suspension system
[AIAA PAPER 88-2316] p 57 A88-32254
WOODGATE, BRUCE E.
The Solar Maximum Mission repair - Lessons learned
p 124 A88-21853
WORDEN, EDSON A.
Initial results of integrated testing of a regenerative ECLSS at MSFC
[SAE PAPER 871454] p 41 A88-21114
WORLEY, H. E.
Design-to-performance p 2 A88-16295
WORLEY, H. EUGENE
Large space structures testing
[AAS PAPER 87-036] p 13 A88-16996
WREN, G. G.
Comparison of experimental techniques in the measurement of damping capacity of metal-matrix composites p 56 A88-31600
WRENN, G. L.
Environmental constraints for Polar Platform design
[IAF PAPER 87-09] p 108 A88-15809
WRIGHT, A. N.
The structure of ULF waves produced by a tethered satellite system p 114 A88-23924
WRIGHT, JEROME L.
OMV servicing missions from Space Station
p 121 A88-15291
WRIGHT, M. A.
Space Station probability of no penetration due to meteoroid and orbital debris impact
[AIAA PAPER 88-2464] p 18 A88-31387
Space station integrated wall design and penetration damage control
[NASA-CR-179169] p 25 N88-10070
WU, K. CHAUNCEY
Preliminary investigation of stability of a fin-stiffened slender strut
[NASA-TM-4034] p 31 N88-19568
WU, S. C.
A finite element method for time varying geometry in multibody structures
[AIAA PAPER 88-2234] p 21 A88-32197
WU, Y. C.
Large deployable reflector thermal characteristics in low earth orbits
[AIAA PAPER 88-0471] p 36 A88-22347
Solar dynamic heat receiver thermal characteristics in low earth orbit
[AIAA PAPER 88-0472] p 71 A88-22348
WYDEVEN, THEODORE
Stability of IRA-45 solid amine resin as a function of carbon dioxide absorption and steam desorption cycling
[SAE PAPER 871452] p 40 A88-21112

X

XU, D. M.
On control of tethered satellite systems
p 110 A88-16294

Y

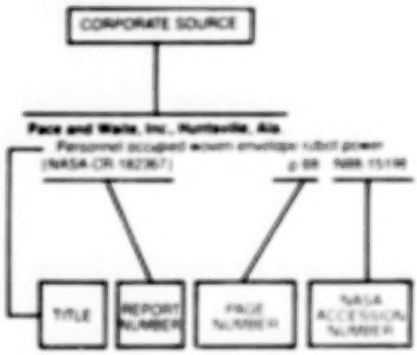
YAMADA, KATSUHIKO
Reduced order models of a large flexible spacecraft
[IAF PAPER 87-356] p 13 A88-16046
Formulation of rigid multibody systems in space
p 14 A88-21221
Formulation methods of rigid multibody systems for large space structures and some results of computer simulation
[NAL-TR-942] p 30 N88-17730
YAMAGUCHI, I.
A unified matrix approach applied to dynamic formulation of complex space structures with nonlinear hinge forces and torques
[IAF PAPER 87-348] p 13 A88-16039
YAMAGUCHI, ISAO
An experimental study on flexible spacecraft three-axis attitude control p 53 A88-26356
Formulation methods of rigid multibody systems for large space structures and some results of computer simulation
[NAL-TR-942] p 30 N88-17730
YANG, Y. J.
An efficient multilevel optimization method for engineering design
[AIAA PAPER 88-2235] p 8 A88-32190
YANDEY, JAMES L.
Simulation and control of a Space Station air revitalization system
[SAE PAPER 871425] p 7 A88-21089
YARDLEY, JOHN F.
Spaceward ho
[AIAA PAPER 88-0750] p 163 A88-22567
YASAKA, TETSUO
Research and development of the tension truss antenna
[IAF PAPER 87-317] p 12 A88-16015
Geostationary tether satellite system and its application to communications systems p 115 A88-28674
Analytical and experimental investigations for satellite antenna deployment mechanisms
[AIAA PAPER 88-2225] p 76 A88-32189
YASUI, M.
Dynamic power generation for solar power satellites
[IAF PAPER 87-253] p 69 A88-15972
YE, XIAOYE
Feedback control for attitude control system of the elastic vehicle p 48 A88-14596
YEDAVALLI, RAMA K.
Robust stabilization under mode truncation and parameter variations p 15 A88-27325
YOKOSHIMA, I.
Proposal of adaptively controlled transmitting array for microwave power transmission in space
p 53 A88-25854
YOKOTA, H.
Dynamics and control during slewing maneuvers
[IAF PAPER 87-353] p 49 A88-16043
YOSHIOKA, T.
Automation and robotics technology application to JEM
[IAF PAPER 87-74] p 136 A88-15849
YOST, RICHARD A.
Monitoring of space station life support systems with miniature mass spectrometry and artificial intelligence
p 45 N88-16376
YOUNG, JOHN W.
Dynamics and control characteristics of a reference Space Station configuration
[AIAA PAPER 88-2495] p 55 A88-31394
YOUNG, R. C.
Rapid toxicity detection in water quality control utilizing automated multispecies biomonitoring for permanent space stations p 44 N88-10948
YOUNGBLOOD, W. W.
Experiments to ensure Space Station fire safety - A challenge
[AIAA PAPER 88-0540] p 155 A88-22405
YOUSUFF, A.
(M,N)-approximation - A system simplification method
p 54 A88-27402
YU, JAMES C.
Structures and materials technology for Space Station
[AIAA PAPER 88-2446] p 17 A88-31377
YU, RUNYI
On local state feedback and stability domain estimation of nonlinear large scale systems p 144 A88-29245
YURKOVICH, STEVE
Active vibration control on the OSU flexible beam
p 15 A88-27357

Z

ZAFRAN, SIDNEY
Orbital Maneuvering Vehicle (OMV) propulsion subsystem
[IAF PAPER 87-261] p 149 A88-15976
ZAGAJA, J. A.
Performance evaluation of SPE electrolyzer for Space Station life support
[SAE PAPER 871451] p 40 A88-21111
ZAITSEV, IU. I.
Intercosmos. An example of cooperation
p 142 A88-24793
ZAITSEV, O. F.
Optimization of the parameters of a solar photoelectric system exposed to cosmic rays p 72 A88-28250
ZAK, MICHAIL
Dispersion, damping and confinement of propagating pulses in large space structures
[AIAA PAPER 88-2311] p 22 A88-32059
ZAKATOV, M. D.
Ballistocardiography in weightlessness research
p 46 N88-19080
ZALOGUYEV, S. N.
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment
p 145 N88-12917
ZANGHI, CLAUDIO
Legal problems of the commercial use of space stations including proprietary rights p 160 A88-13492
ZELTWANGER, UWE
The Soviet space flight project MIR
p 139 A88-20564
ZHANG, JIA J.
Wave propagation experiments on 22-bay lattice
[AD-A186140] p 29 N88-15002
ZHANG, YONGXING
The component-mode method in a parallel computer environment
[AIAA PAPER 88-2438] p 8 A88-32355
ZHU, S.
Ignition and combustion of metals in oxygen
p 79 N88-12530
ZIMMERMAN, D. C.
Low authority-threshold control for large flexible structures
[AIAA PAPER 88-2270] p 22 A88-32235
ZUZEK, JOHN E.
An allotment planning concept and related computer software for planning the fixed satellite service at the 1988 space WARC
[NASA-TM-100244] p 165 N88-11944
ZYLSTRA, STEVEN
Ross-Stirling engine - A high performance dynamic space power system p 63 A88-11797

252

Typical Corporate Source Index Listing



Listings in this index are arranged alphabetically by corporate source. The title of the document is used to provide a brief description of the subject matter. The page number and the accession number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document.

A

Aeritalia S.p.A., Naples (Italy).
Columbus preparatory program: Payload element study on a technology demonstration mission, executive summary
(CS-RP-AI-016) p 145 N89-10080
Columbus pressurized module utilization study, executive summary
(CS-RP-AI-027) p 146 N89-15005

Aeritalia S.p.A., Rome (Italy).
Columbus pressurized module verification
p 145 N89-10842

Aeritalia S.p.A., Turin (Italy).
Columbus feasibility studies. Volume 1: Requirements and system concept
(ETN-88-91073) p 146 N89-16790
Columbus feasibility studies. Volume 2: Element constituents, mechanical
(ETN-88-91074) p 146 N89-16800
Columbus feasibility studies. Volume 3: Avionics, systems
(ETN-88-91075) p 146 N89-16801
Columbus feasibility studies. Volume 5: Programmatics
(ETN-88-91076) p 147 N89-16802
Study on long term evolution towards European manned space flight. Volume 1: Executive summary
(MSB-RA3-004/87-VOL-1) p 147 N89-17589

Aerospace Corp., El Segundo, Calif.
The combined release and radiation effects satellite, a joint NASA/DOD program
p 131 N89-10851

Air Force Astronautics Lab., Edwards AFB, Calif.
AF cryogenic and fluid management spacecraft technology program
p 80 N89-10925

Air Force Geophysics Lab., Hanscom AFB, Mass.
The effect of photoelectrons on boom-satellite potential differences during electron beam ejection
(AD-A190390) p 75 A88-20350

Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
Critical issues for establishment of a permanently occupied lunar base
(AD-A187128) p 107 N88-17567

Air Force Space Div., Los Angeles, Calif.
Space Assembly, Maintenance, and Servicing Study (SAMSS)
p 125 N89-10089

Alabama Univ., Huntsville.
Robustness of active modal damping of large flexible structures
p 11 A89-13929
A measurement of the angular distribution of 5-eV atomic oxygen scattered off a solid surface in earth orbit
p 130 A88-16864
Analysis of oblique hypervelocity impact phenomena
(AIAA PAPER 88-2370) p 23 A88-32307
Teleoperator and robotics system analysis
(NASA-CR-179020) p 97 N89-12105
Personnel occupied woven envelope robot power
(NASA-CR-182367) p 88 N89-15196
Use of hydrophilic polymer coatings for control of electroosmosis and protein adsorption
p 119 N89-15620
Goal driven kinematic simulation of flexible arm robot for space station missions
p 89 N89-16386
Solid modelling for the manipulative robot arm (power) and adaptive vision control for space station missions
p 89 N89-16409
Intelligent man machine interfaces on the space station
p 90 N89-16418
Analysis of low gravity tolerance of model experiments for space station: Preliminary results for directional solidification
(NASA-CR-182657) p 10 N89-19648
CMSy man system simulation integration: A preliminary analysis and recommendation
(NASA-CR-182602) p 151 N89-20005

Alabama Univ., Tuscaloosa.
Stochastic model of the NASA/MSFC ground facility for large space structures with uncertain parameters: The maximum entropy approach
(NASA-CR-181490) p 27 N88-12343

Analex Corp., Fairview Park, Ohio.
Space environmental considerations for a long term cryogenic storage vessel
p 90 N88-15833

Analytical Mechanics Associates, Inc., Hampton, Va.
The Aeroassist Flight Experiment
(AF PAPER 87-197) p 2 A88-15934
Downward-deployed tethered platforms for high enthalpy aerothermodynamic research
(AIAA PAPER 88-0669) p 114 A88-22514
Steady state micro-g environment on Space Station
(AIAA PAPER 88-2462) p 4 A88-31385
The impact of asymmetric physical properties on large space structures
(AIAA PAPER 88-2496) p 19 A88-31395
Orbit lifetime characteristics for Space Station
(AIAA PAPER 88-2650) p 55 A88-31399

Arizona State Univ., Tempe.
Planetary science
p 5 N88-15356

Army Construction Engineering Research Lab., Champaign, Ill.
Investigation of design concepts for large space structures to support military applications
(AD-A186088) p 29 N88-15000
State-of-the-art technologies for construction in space. A review
(AD-A188412) p 31 N88-19483

Astro International Corp., Houston, Tex.
Recent developments in water quality monitoring for Space Station reclaimed wastewaters
(SAE PAPER 871447) p 40 A88-21107

Auburn Univ., Ala.
An investigation of the damping phenomena in wire rope isolators
p 21 A89-31597
Experimental study of damping of graphite epoxy composite material of the Space Telescope truss system
p 56 A89-31605
Development of a graphical display on the DMS test bed
p 101 N88-14864
Planning activities in space
p 9 N89-10417
A two stage launch vehicle for use as an advanced space transportation system for logistics support of the space station
(NASA-CR-182572) p 107 N88-18606
A lunar transportation system
(NASA-CR-182581) p 107 N89-19379

B

Ball Aerospace Systems Div., Boulder, Colo.
Phase 3 study of selected tether applications in space. Volume 2: Study results
(NASA-CR-179196) p 116 N89-10629
Electrodynamic tether system study
(NASA-CR-172524) p 117 N89-11737

Battelle Inst., Frankfurt am Main (West Germany).
Allowable gravity levels for Spacelab, Columbus and EURECA
(BF-R-66.525-2) p 132 N88-15084
Study on long term evolution towards European manned space flight. Volume 1: Executive summary
(MSB-RA3-004/87-VOL-1) p 147 N89-17589

BDM Corp., Columbia, Md.
Hubble Space Telescope servicing: Experience base for a new era
(AF PAPER 87-38) p 109 A88-15829

Bergen Univ. (Norway).
AURO: A proposal for flying aurora imaging observatory on the Polar Platform in the Space Station Columbus program
p 119 N89-16268

Bionetics Corp., Hampton, Va.
Analysis of a rotating advanced technology space station for the year 2025
(NASA-CR-178345) p 107 N89-19080

Bionetics Corp., Moffett Field, Calif.
OSSA Space Station waste inventory
(SAE PAPER 871413) p 39 A88-21078
Water management requirements for animal and plant maintenance on the Space Station
(SAE PAPER 871469) p 41 A88-21125
Telescience testbedding for life science missions on the Space Station
(AIAA PAPER 88-0446) p 86 A88-22332

Boeing Aerospace Co., Huntsville, Ala.
Foundation: Transforming data bases into knowledge bases
p 102 N89-16423

Boeing Aerospace Co., Seattle, Wash.
Protective coatings for composite tubes in space applications
p 94 A89-13239
Hypervelocity impact damage assessment for Space Station
(AIAA PAPER 89-2455) p 19 A89-31388
Space station integrated wall design and penetration damage control
(NASA-CR-179169) p 25 N89-10070
Controlled Ecological Life Support Systems (CELSS) conceptual design option study
(NASA-CR-177421) p 44 N89-14625
Controlled Ecological Life Support Systems (CELSS) physiochemical waste management systems evaluation
(NASA-CR-177422) p 45 N89-14626
Chromic acid anodizing of aluminum foil
(NASA-CR-179417) p 97 N89-15077
Space station integrated wall damage and penetration damage control. Task 5: Space debris measurement, mapping and characterization system
(NASA-CR-179281) p 30 N89-17088
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 1: Executive summary. Phase A: Conceptual design and programmatics
(NASA-CR-179268) p 104 N89-17721
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 2: Study results, attachment 2. Phase A: Conceptual design and programmatics
(NASA-CR-179272) p 46 N89-17722

System analysis study of space platform and station accommodations for life sciences research facilities. Volume 2: Study results. Appendix E: Work breakdown structure and dictionary
[NASA-CR-179274] p 46 N88-17723
System analysis study of space platform and station accommodations for life sciences research facilities. Volume 2: Study results. Appendix D: Life sciences research facility requirements
[NASA-CR-179273] p 46 N88-17724

Boeing Co., Huntsville, Ala.
FMEAssist: A knowledge-based approach to Failure Modes and Effects Analysis p 101 N88-16395

Boeing Co., Seattle, Wash.
Space Station pressure wall repair techniques
[AIAA PAPER 88-2488] p 19 A88-31397

British Aerospace Dynamics Group, Bristol (England).
Study of large solar arrays (SCILA), phase 2A
[BAE-SS/1109] p 74 N88-17106
Study of Large Solar Arrays (SCILA) Phase 2A. Amplifying information to final report (SS/1109)
[BAE-SS/1110] p 74 N88-17480

British Aerospace Dynamics Group, Stevenage (England).
Study on long term evolution towards European manned space flight. Volume 1: Executive summary
[MBB-RA3-004/87-VOL-1] p 147 N88-17689

British Aerospace Public Ltd. Co., Bristol (England).
EVA, the technological challenge p 128 N88-19535

British Aerospace Public Ltd. Co., Stevenage (England).
Teleoperation and control study
[BAC-TP-6268] p 97 N88-10489
A teleoperated manipulator system's concept for unmanned platforms p 94 N88-19537

Brown Univ., Providence, R. I.
Computational methods for problems in aerodynamics and large space structure using parallel and vector architectures
[AD-A185401] p 27 N88-13294

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[AIAA PAPER 88-2494] p 55 A88-31393

C

California Univ., Berkeley.
Social factors in space station missions p 46 N88-19868

California Univ., Los Angeles.
Disturbance and vibration isolation in space stations by means of mechanical decoupling p 11 A88-13832
Control-augmented structural synthesis
[AIAA PAPER 88-1014] p 55 A88-28043

California Univ., Santa Barbara.
An efficient multilevel optimization method for engineering design
[AIAA PAPER 88-2226] p 9 A88-32190

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Transient response of joint dominated space structures - A new linearization technique
[AIAA PAPER 88-2389] p 24 A88-32325

Case Western Reserve Univ., Cleveland, Ohio.
Maneuvering and vibration control of flexible spacecraft p 52 A88-22932
Degradation mechanisms of materials for large space systems in low Earth orbit
[NASA-CR-181472] p 90 N88-10896

Catholic Univ. of America, Washington, D.C.
Optimal control of large space structures via generalized inverse matrix
[NASA-CR-182336] p 59 N88-13907
Cartesian path control of a two-degree-of-freedom robot manipulator
[NASA-CR-182331] p 98 N88-13908

Central Research Labs., Red Wing, Minn.
Remote repair demonstration of Solar Maximum main electronics box p 128 N88-19510

Centre d'Etude Spatiale des Rayonnements, Toulouse (France).
Spacecraft surface exposure to atomic oxygen in low Earth orbit p 96 N88-11710
External surface charging mechanisms
p 132 N88-11719
Discharge phenomena p 132 N88-11723

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Antibiotic activity in space, results and hypothesis
p 159 N88-19852

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[ISBN-2-85428-170-5] p 132 N88-11702
The high performance solar array GSRS
[SNIAS-672-422-108] p 73 N88-13814

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Study of fault tolerant techniques for satellite data handling
[FTT/REP/0001/SAAB] p 101 N88-13860

Cincinnati Univ., Ohio.
Simultaneous structural and control optimization via linear quadratic regulator eigenstructure assignment
p 28 N88-13822

Clarkson Univ., Potsdam, N.Y.
Computer-aided modeling and prediction of performance of the modified Lundell class of alternators in space station solar dynamic power systems
[NASA-CR-182538] p 74 N88-19330

Cleveland State Univ., Ohio.
A novel photovoltaic power system which uses a large area concentrator mirror p 65 A88-11811
Modeling the performance of the monogroove with screen heat pipe for use in the radiator of the solar dynamic power system of the NASA Space Station
[AF PAPER 87-238] p 34 A88-15980
Oxidation-resistant reflective surfaces for solar dynamic power generation in near earth orbit p 70 A88-16523

College of William and Mary, Williamsburg, Va.
Space environmental effects on polymeric materials
[NASA-CR-182418] p 97 N88-15082
Space environmental effects on polymeric materials
[NASA-CR-182454] p 97 N88-16879

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Remote sensing Earth's surface and atmosphere; Proceedings of Workshop II and the Topical Meeting of the 26th COSPAR Plenary Meeting, Toulouse, France, June 30-July 11, 1986 p 111 A88-17026

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Structural tailoring and feedback control synthesis - An interdisciplinary approach
[AIAA PAPER 88-2236] p 21 A88-32177
Robust controller design for flexible structures
[AD-A187217] p 30 N88-19039

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p 166 N88-12424
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p 166 N88-12425
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[S-HRG-100-329] p 166 N88-14043

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[GPO-80-245] p 166 N88-14044
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[PUB-LAW-100-147] p 165 N88-12402

Computer Sciences Corp., Beltsville, Md.
The resource envelope as a basis for space station management system scheduling p 102 N88-16427

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The GSFC Flight Support System for on-orbit satellite servicing
[AIAA PAPER 88-0446] p 124 A88-22334

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AUTOPLAN - A PC-based automated mission planning tool p 7 A88-20486

Contes, Grafton, Va.
A finite element method for time varying geometry in multibody structures
[AIAA PAPER 88-2234] p 21 A88-32197

Consiglio Nazionale delle Ricerche, Florence (Italy).
SAFIRE - A novel high resolution cooled spectrometer for atmospheric research
[AF PAPER 87-137] p 109 A8 -15804

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Recent developments in gravity gradiometry from the Space-Shuttle-borne tethered satellite system
p 112 A88-21031
Research on Electrodynamic Tether Effects (RETE) experiment Electrical Ground Support Equipment (EGSE)
[IFSI-87-2] p 150 N88-13378
Mechanical design of the ac bracket package for the RETE experiment
[IFSI-87-4] p 145 N88-13379
RETE experiment Assembly, Integration, and Verification (AIV) activities
[IFSI-87-6] p 117 N88-13380
Laboratory simulation of the electrodynamic interactions of a tethered satellite with an ionospheric plasma
[IFSI-85-3] p 119 N88-15822

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Analytical interactive approach for phenomena involving structures, thermal and control aspects. Volume 1: Theory
[ESA-CR(P)-2503-VOL-1] p 60 N88-10802
Analytical interactive approach for phenomena involving structures, thermal and control aspects. Volume 2: Toward the solution
[ESA-CR(P)-2503-VOL-2] p 60 N88-10804
Analytical interactive approach for phenomena involving structures, thermal, and control aspects. Volume 3: Executive summary
[ESA-CR(P)-2503-VOL-3] p 60 N88-10805

Control Dynamics Co., Huntsville, Ala.
Large space structures testing
[AAS PAPER 87-036] p 13 A88-16096

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Control design challenges of large space systems and spacecraft control laboratory experiment (SCOLE)
[NASA-CR-178392] p 58 N88-11735

D

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European activities in exobiological research in space
p 158 N88-19829
Radiation problems in manned space flight with a view to the Space Station p 132 N88-19834
Implications of shiftwork in space for human physiology experiments p 129 N88-19842
Microgravity User Support Center (MUSC) for EURECA, Spacelab and Columbus missions p 149 N88-19847

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Safe rendezvous approach to a space station by impulsive transfers and continuous thrust arcs
p 151 N88-19496
EPOS: European Proximity Operations Simulation
p 147 N88-19515

Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
Study of a payload for Columbus Polar Platform Earth observation demonstration mission, executive summary
[ESA-CR(P)-2412] p 118 N88-10079
Preliminary study of a containerless processing facility for Columbus, executive summary
[ESA-ITT-AO/1-1.804/85/F] p 96 N88-10203
Prephase A study of a crystallization laboratory for Columbus, executive summary
[ESA-ITT-AO/1-1866/85/F] p 96 N88-10256
X-band SAR for a European remote sensing payload
p 117 N88-12142
Progress in European CELSS activities
p 44 N88-12252
Docking Berthing Subsystem (DBS). Development part 1: Latching analysis
[ESA-CR(P)-2479] p 60 N88-19825
Columbus feasibility studies. Volume 1: Requirements and system concept
[ETN-88-91073] p 146 N88-16799
Columbus feasibility studies. Volume 2: Element constituents, mechanical
[ETN-88-91074] p 146 N88-16800
Columbus feasibility studies. Volume 3: Avionics, systems
[ETN-88-91075] p 146 N88-16801
Columbus feasibility studies. Volume 5: Programmatics
[ETN-88-91076] p 147 N88-16802
Multisurface control mechanism for a deployable antenna. Far Infrared and Submillimeter Space Telescope (FIRST) technology study
[RP-IFA-0003] p 120 N88-19807
Study on long term evolution towards European manned space flight. Volume 1: Executive summary
[MBB-RA3-004/87-VOL-1] p 147 N88-17689
Development of the Extendable and Retractable Mast (ERM). Design phase 2. Volume 1
[RP-2010-0000-DS/09] p 31 N88-18700

Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
A free-flying power plant for a manned space station
p 70 A88-16308
Information prioritization for control and automation of space operations p 66 A88-27355

Efficient placement of structural dynamics sensors on the space station
[NASA-CR-172015] p 25 N88-10103
Predictive momentum management for a space station measurement and computation requirements
[NASA-CR-172029] p 58 N88-10866

Duke Univ., Durham, N. C.
Three parallel computation methods for structural vibration analysis
[AIAA PAPER 88-2391] p 24 A88-32323

E

EMTECH Corp., Dallas-Fort Worth Airport, Tex.
Development of an advanced photovoltaic concentrator system for space applications p 65 A88-11812

Erlangen-Nuremberg Univ. (West Germany).
ISIS: Imaging Spectrle Interferometer in Space p 115 N88-10625

Erno Raumfahrttechnik G.m.b.H., Bremen (West Germany).
Man-Tended Free Flyer operational design features p 129 N88-10486
Mission profiles of the MTFF co-orbiting with the US Space Station p 9 N88-10487
Automatic in-orbit payload deployment mechanisms, logistic operations and transport vehicle design compatibilities p 52 N88-10490
Treatment of unforeseen situations by online knowledge-based diagnostic systems p 93 N88-10511
Columbus Simulation Facility (CSF) p 146 N88-10522
Rendezvous and docking (RvD) verification and demonstration in-orbit p 62 N88-10531
External payload servicing: Operational requirements and technology p 129 N88-10541

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Report on the scientific satellites of the European Space Agency
[ESA-SP-1090] p 116 N88-10091
Commercial Opportunities for Remote Sensing with Polar Platforms
[ESA-SP-269] p 117 N88-12131
Possible commercial use of the polar platforms p 165 N88-12132
Interoperability and integration of data relay satellite systems p 76 N88-12134
Legal protection of the Polar Platform's users p 145 N88-12135
ESA Bulletin No. 25
[ISSN-0376-4265] p 146 N88-16767
Proceedings of the ESA Workshop on Co-Orbiting Platform Elements (COPE)
[ESA-SP-1090] p 146 N88-16777
Polar platform element of Space Station: Mission objectives, European priorities, candidate instrumentation and selection procedure p 119 N88-16779
Space station overview p 167 N88-16780
Use of Space Station for space science p 121 N88-16782
Microgravity payloads and missions for Space Station: Some issues affecting compatibility with other payloads p 120 N88-16783
The Columbus program, an overview p 146 N88-16784
Proceedings of the 1st European In-Orbit Operations Technology Symposium
[ESA-SP-272] p 126 N88-19484
The European Space Agency's role in life sciences and research in space p 148 N88-19694
Life sciences in the framework of the ESA microgravity program and future flight opportunities p 148 N88-19695

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Safe and fuel minimum reference trajectories for closed loop controlled approaches p 61 N88-19499

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Space station based interferometry p 116 N88-10629
Environmental interactions of solar generators in space p 72 N88-11730
Discharge prevention of geosynchronous orbit conductive thermal control materials and grounding systems p 76 N88-11732
Payload configurations and serviceability p 117 N88-12133
Technical aspects of future ocean colour remote sensing p 119 N88-16298
Applications of expert systems for satellite autonomy p 80 N88-16443
Why mechanisms are critical to spacecraft performance p 90 N88-16737
Satellite assembly in geostationary orbit: A plug-and-socket concept p 127 N88-16759
Satellite power systems under consideration by the United Nations p 74 N88-16773
An overview of the current Earth observation programs (Europe, USA, and Japan) p 167 N88-16779
Tethers: An outline of a new concept for Earth observation p 130 N88-16791
Motion simulation for in-orbit operations p 62 N88-19514
EUROSIM: A design concept for an in-orbit operations simulator p 148 N88-19517
Man-tended options for European space robotics p 94 N88-19538
Exobiology and botany facilities for EURECA p 148 N88-19698

F

Factory Mutual Research Corp., Norwood, Mass.
Fire extinguishment and inhibition in spacecraft environments p 156 N88-12523

Fairchild Space and Electronics Co., Germantown, Md.
Orbital Spacecraft Consumables Resupply System p 122 A88-15292
Technology advancements for servicing of future spacecraft systems
[AF PAPER 87-36] p 122 A88-15826

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Low authority threshold control for large flexible structures
[AIAA PAPER 88-2270] p 22 A88-32226

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Thermal structural control modelling techniques
[FOK-TR-R-88-030] p 38 N88-15809
The ESA/Fokker service end effector subsystem: A robotic/man-compatible servicing approach p 92 N88-19502

Ford Aerospace and Communications Corp., Palo Alto, Calif.
Geostationary earth observations - Platform operations from the Space Station
[AF PAPER 87-19] p 108 A88-15814
Economic benefits of the Space Station to commercial communication satellite operators
[AF PAPER 87-622] p 163 A88-16215
The economics of satellite retrieval
[AIAA PAPER 88-0843] p 164 A88-27584
Communications satellite systems operations with the space station. Volume 3: Supplementary technical report
[NASA-CR-180875] p 77 N88-16794

G

Galveston Coll., Tex.
A solid phase enzyme-linked immunosorbent assay for the antigenic detection of Legionella pneumophila (serogroup 1): A complement for the space station diagnostic capability p 157 N88-14868

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Space station: National Aeronautics and Space Administration's 1987 cost estimate
[PB87-220760] p 165 N88-10893

General Dynamics Corp., San Diego, Calif.
Control considerations for high frequency, resonant, power processing equipment used in large systems p 47 A88-11929
The ac power system tech...
[NASA-CR-175068] p 72 N88-11948
Large capacity cryopropellant orbital storage facility p 80 N88-15932

General Elec[illegible] Co., Philadelphia, Pa.
Space station ... Forms p 116 N88-10096

General Electric Co., Schenectady, N.Y.
Oxidation-resistant reflective surfaces for solar dynamic power generation in near earth orbit p 70 A88-18520

General Research Corp., Huntsville, Ala.
Prototype resupply scheduler p 9 N88-16429

General Research Corp., McLean, Va.
Spacecraft technology trends - A view from the past
[AF PAPER 87-07] p 101 A88-15807
In-space research, technology and engineering experiments and Space Station p 3 A88-27750
Tethers in space handbook
[NASA-CR-181571] p 118 N88-14123

General Sciences Corp., Laurel, Md.
Efficient spacecraft formationkeeping with consideration of ballistic coefficient control
[AIAA PAPER 88-0375] p 104 A88-23377

G

Georgia Inst. of Tech., Atlanta.
Development of an emulation-simulation thermal control model for space station application
[NASA-CR-182409] p 37 N88-15823

Globex, Inc., Reston, Va.
Remote sensing: Earth's surface and atmosphere. Proceedings of Workshop II and the Topical Meeting of the 26th COSPAR Plenary Meeting, Toulouse, France, June 30-July 11, 1986 p 111 A88-17026

Grumman Aerospace Corp., Bethpage, N.Y.
Heat pipe radiators for solar dynamic space power system heat rejection p 33 A88-11807
Design of an ammonia two-phase Prototype Thermal Bus for Space Station
[SAE PAPER 871508] p 35 A88-21152
High thermal-transport capacity heat pipes for space radiators
[SAE PAPER 871509] p 35 A88-21155
Thermal Control Working Group report p 36 N88-13094

H

Hamilton Standard, Windsor Locks, Conn.
Simulation and control of a Space Station air revitalization system
[SAE PAPER 871425] p 7 A88-21089
Thermoelectric integrated membrane evaporation subsystem testing
[SAE PAPER 871446] p 40 A88-21106
Performance evaluation of SPE electrolyzer for Space Station life support
[SAE PAPER 871451] p 40 A88-21111

Hamilton Standard Div., United Aircraft Corp., Windsor Locks, Conn.
Development of a regenerable humidity and CO2 control system for an advanced EMU
[SAE PAPER 871471] p 41 A88-21127

Harris Corp., Melbourne, Fla.
Solar concentrator advanced development project p 64 A88-11790
Development of composite facets for the surface of a space-based solar dynamic concentrator p 70 A88-18230
Maximum entropy/optimal projection design synthesis for decentralized control of large space structures
[AD-A186359] p 29 N88-15083
Solar concentrator advanced development program, task 1
[NASA-CR-179489] p 74 N88-19368

Harvard-Smithsonian Center for Astrophysics, Cambridge, Mass.
Recent developments in gravity gradiometry from the Space Shuttle-borne tethered satellite system p 112 A88-21501
Alfven waves from an electrodynamic tethered satellite system p 115 A88-25890

Heer Associates, Inc., LaCanada, Calif.
Progress towards autonomous, intelligent systems
[AF PAPER 87-31] p 83 A88-15823

Hernandez Engineering G.m.b.H., Bonn (West Germany).
Safety philosophy, policy, and requirements for manned spaceflight. Volume 1: Executive summary
[HEG-0886/1036-VOL-1] p 157 N88-15826

Honeywell, Inc., Clearwater, Fla.
Pinhole occulter experiment
[NASA-CR-179256] p 116 N88-11491
Approaches and possible improvements in the area of multibody dynamics modeling
[NASA-CR-179227] p 29 N88-14387
Prototype space station automation system delivered and demonstrated at NASA p 45 N88-16442

Honeywell, Inc., Glendale, Ariz.
Viscous damped space structure for reduced jitter p 28 N88-13623

Houston Univ., Tex.
Space station software reliability analysis based on failures observed during testing at the multisystem integration facility p 101 N88-14884

Howard Univ., Washington, D. C.
The dynamics and control of large space structures after the onset of thermal shock
[AF PAPER 87-351] p 49 A88-16041
Minimum time attitude slewing maneuvers of a rigid spacecraft
[AIAA PAPER 88-0675] p 52 A88-22505
Nondestructive construction error detection in large space structures
[AIAA PAPER 88-2460] p 18 A88-31383
The dynamics and control of large flexible space structures, part 10
[NASA-CR-182438] p 29 N88-15830

Hughes Aircraft Co., Torrance, Calif.
Hybrid honeycomb panel heat rejection system
[SAE PAPER 871419] p 34 A88-21083
Advanced radiator concepts utilizing honeycomb panel heat pipes
[NASA-CR-172817] p 37 N88-12747
Hunting Technical Services Ltd., Borehamwood (England).
Confidentiality of data p 145 N88-12136

I

Illinois Univ., Urbana.
Design of low order controllers for robust disturbance rejection in large space structures
[AD-A185202] p 59 N88-13376
Institute of Biomedical Problems, Moscow (USSR).
MedLab: A project of a medical laboratory in space p 159 N88-19946
Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil).
Construction aspects of testbeds for attitude control systems simulation of artificial satellites
[INPE-4283-PRE/1155] p 61 N88-19616
Simulation and tests of a satellite attitude and orbit control system. General considerations concerning an example case (INPE) and design of a servo rate table
[INPE-4282-PRE/1154] p 62 N88-19572
International Technology, Washington, D.C.
Review of commercial spacecraft: Recovery and repair experiences. Implications for future spacecraft designs and operations p 128 N88-19539
Iowa Univ., Iowa City.
Dynamics and control of a planar truss actuator p 55 A88-31564
Italspazio, Rome (Italy).
Study of mobile communications payload for Columbus Polar Platforms
[ITS-TR-056A/86] p 76 N88-10220

J

Jet Propulsion Lab., California Inst. of Tech., Pasadena.
Advanced photovoltaic solar array design p 60 A88-11793
Research opportunities in microgravity science and applications during Shuttle hiatus p 108 A88-13164
NASA's Telerobotics R & D Program - Status and future directions
[IAF PAPER 87-24] p 62 A88-15816
Science on the Space Station: The opportunity and the challenge - A NASA view
[IAF PAPER 87-02] p 99 A88-15863
Optimal trajectories for aeroassisted, noncoplanar orbital transfer. II - LEO-to-LEO transfer
[IAF PAPER 87-328] p 49 A88-16024
Space telerobotics technology demonstration program
[AAS PAPER 87-045] p 64 A88-17030
Verification of large beam-type space structures p 14 A88-19837
Autonomy, automation, and systems p 85 A88-21640
PLAN-IT - Knowledge-based mission sequencing p 7 A88-21644
A technique to aid in the design of optimal robots for use in space applications p 85 A88-21648
Computing architecture for telerobots in earth orbit p 99 A88-21650
The NASA telerobot technology demonstrator p 85 A88-21651
OSSA's Telescience concept for the Space Station era
[AIAA PAPER 88-0120] p 112 A88-22083
Large deployable reflector thermal characteristics in low earth orbits
[AIAA PAPER 88-0471] p 36 A88-22347
Solar dynamic heat receiver thermal characteristics in low earth orbit
[AIAA PAPER 88-0472] p 71 A88-22148
Experimental studies of active members in control of large space structures
[AIAA PAPER 88-2267] p 58 A88-22178
Dispersion, damping and confinement of propagating pulses in large space structures
[AIAA PAPER 88-2311] p 22 A88-22259
Multiple boundary condition test (MBCT) - Identification with mode shapes
[AIAA PAPER 88-2350] p 23 A88-22290
Passive damping for space truss structures
[AIAA PAPER 88-2469] p 24 A88-22360
Telerobotics p 86 N88-19090
Wavefront error sensing
[NASA-CR-181504] p 76 N88-12030
Design concepts for bioreactors in space p 45 N88-17179
Joint Publications Research Service, Arlington, Va.
USSR report: Space
[JPRS-USP-87-003] p 144 N88-10650
Beagle commentary on Mir station, first manning p 144 N88-10651
X-ray astronomy instruments to operate on Mir station p 144 N88-10652
Solar converging method p 37 N88-12504
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment p 145 N88-12917
JPRS report: Science and technology USSR Space
[JPRS-USP-87-006] p 146 N88-16363
Gyrostabilizer system of Kvant module p 60 N88-16390
Balistocardiography in weightlessness research p 46 N88-19080

K

Kalil (Michael) Design Studio, New York, N.Y.
Space station architectural elements model study
[REPT 01799] p 10 N88-19885
Kampsax Int., Copenhagen (Denmark).
Study on long term evolution towards European manned space flight. Volume 1: Executive summary
[MSS-RA3-004/87-s(Ch.-1)] p 147 N88-17683
Karlsruhe Univ. (West Germany).
Mobile robot activity model for autonomous free flying platforms p 92 N88-19507
Keio Univ., Yokohama (Japan).
Sunlight supply and gas exchange systems in microalgal bioreactor p 64 N88-12058
Krug International, Houston, Tex.
Inflight microbial analysis technology
[SAE PAPER 871493] p 42 A88-21147

L

LABEN Space Instrumentation and Systems, Milan (Italy).
Expert system study for spacecraft management
[TI. 2699-ISS-1] p 101 N88-15004
Robotic intelligence issues for space manipulator monitoring, control programming p 92 N88-19504
Life Systems, Inc., Cleveland, Ohio.
Environmental control and life support system requirements and technology needs for advanced manned space missions
[SAE PAPER 871433] p 39 A88-21096
Electrochemically regenerable carbon dioxide/moisture control technology for an Advanced Extravehicular Mobility Unit
[SAE PAPER 871470] p 41 A88-21126
Little (Arthur D.), Inc., Cambridge, Mass.
Performance characteristics of moving belt radiators p 33 A88-12008
Lockheed Engineering and Management Services Co., Inc., Houston, Tex.
Space Station Active Thermal Control System modeling
[AIAA PAPER 88-0473] p 38 A88-22349
Lockheed-Georgia Co., Marietta.
Carbon Dioxide observational platform system (CO-OPS) Feasibility Study
[NASA-CR-179225] p 118 N88-14113
Feasibility study of a carbon dioxide observational platform system. Volume 2: Programmatics
[NASA-CR-180404] p 118 N88-14114
Lockheed Missiles and Space Co., Huntsville, Ala.
Preliminary analysis of an integrated logistics system for OSSA payloads
[NASA-CR-4114] p 6 N88-10477
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 1: Executive summary p 6 N88-10478
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 2: OSSA integrated logistics support strategy p 6 N88-10479
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 3: OSSA integrated logistics support planning document p 6 N88-10480
Preliminary analysis of an integrated logistics system for OSSA payloads. Volume 4: Supportability analysis of the 1.9m centrifuge p 6 N88-10481
Lockheed Missiles and Space Co., Sunnyvale, Calif.
Space erectable radiator system development
[AIAA PAPER 88-0469] p 36 A88-22345
Development and properties of aluminum-clad graphite/epoxy tubes for space structures
[AIAA PAPER 88-0472] p 19 A88-31389
Space Station - A focus for the development of structural dynamics scale model technology for large flexible space structures
[AIAA PAPER 88-2483] p 19 A88-31392
Space station accommodations for life sciences research facilities. Phase 1: Conceptual design and programmatics studies for Missions SAAM0307, SAAM0302 and the transition from SAAM0307 to SAAM0302. Volume 2: Study results
[NASA-CR-178244] p 104 N88-15828
Conceptual design and programmatics studies of space station accommodations for Life Sciences Research Facilities (LSRF)
[NASA-CR-178270] p 46 N88-19567
Space station accommodations for life sciences research facilities. Phase 2: conceptual design and programmatics studies for Missions SAAM0307, SAAM0302 and the transition from SAAM0307 to SAAM0302. Volume 1: Executive summary
[NASA-CR-179267] p 104 N88-19571
Logica Ltd., Cobham (England).
Commercial perspective of an imaging spectrometer development program p 160 N88-12138
Los Alamos National Lab., N. Mex.
Integrated heat pipe-thermal storage system performance evaluation p 32 A88-11803
A lunar laboratory p 105 A88-29196
Loyola Univ., Chicago, Ill.
Crew productivity issues in long-duration space flight
[AIAA PAPER 88-0444] p 154 A88-22335
LTV Aerospace and Defense Co., Dallas, Tex.
Radiator selection for Space Station Solar Dynamic Power Systems p 32 A88-11808
LTV Missiles and Electronics Group, Dallas, Tex.
Space station body mounted radiator design
[SAE PAPER 871507] p 35 A88-21153
Thermal contact conductance of pressurized surfaces
[AIAA PAPER 88-0467] p 36 A88-22343
Space erectable radiator system development
[AIAA PAPER 88-0469] p 36 A88-22345
Lunar and Planetary Inst., Houston, Tex.
Progress toward a cosmic dust collection facility on space station
[NASA-CR-182407] p 121 N88-19068

M

Management and Technical Services Co., Houston, Tex.
Life sciences biomedical research planning for Space Station
[SAE PAPER 871464] p 153 A88-21122
Biotechnology opportunities on Space Station
[SAE PAPER 871468] p 154 A88-21124
Martin Marietta Aerospace, Denver, Colo.
Space station integrated propulsion and fluid system study. Fluid systems configuration databook
[NASA-CR-179215] p 79 N88-11753
Concept definition study for recovery of tumbling satellites. Volume 1: Executive summary, study results
[NASA-CR-179228] p 127 N88-14116
Space station onboard propulsion system: Technology study
[NASA-CR-179233] p 40 N88-15006
Servicer system demonstration plan and capability development
[NASA-CR-179246] p 127 N88-19895
The integration of a mesh reflector to a 15-foot box truss structure. Task 3: Box truss analysis and technology development
[NASA-CR-179229] p 31 N88-19941
Martin Marietta Aerospace, New Orleans, La.
STS propellant scavenging systems study. Part 2, volume 2: Cost and WBS/dictionary
[NASA-CR-179276] p 91 N88-17717
Martin Marietta Corp., Denver, Colo.
Human exploration of Mars
[AIAA PAPER 88-0364] p 155 A88-22044
Telepresence work station system definition study, part 2
[NASA-CR-179506] p 4 N88-10871
Orbital Spacecraft Consumables Resupply System (OSCRS): Monopropellant application to space station and OMV automatic refueling impacts of an ELV launch, volume 4
[NASA-CR-179529] p 126 N88-11741
Feasibility study for gas-grain simulation facility
[NASA-CR-177468] p 26 N88-15954
Orbiter transfer vehicle concept definition and system analysis study. Volume 4: Space station accommodations. Revision 1
[NASA-CR-179293] p 150 N88-18629

256

Orbital transfer vehicle concept definition and system analysis study. Volume 4: Appendix A: Space station accommodations. Revision 1
(NASA-CR-179294) p 150 N88-19810

Massachusetts Inst. of Tech., Cambridge.

Plasma contactors for use with electrodynamic tethers for power generation
(IAF PAPER 87-701) p 63 A88-11975

Experimental component mode synthesis of structures with floppy joints
(AIAA PAPER 88-2011) p 24 A88-32339

Effect of joint damping and joint nonlinearity on the dynamics of space structures
(AIAA PAPER 88-2480) p 57 A88-32342

Structural Assembly Demonstration Experiment (SADE)
(NASA-CR-179205) p 26 N88-13868

Experimental assembly of structures in EVA: Hardware methodology and development issues p 26 N88-13872

EASE (Experimental Assembly of Structures in EVA): overview of selected results p 129 N88-13881

Survey on large scale system control methods
(NASA-CR-181156) p 58 N88-13374

Plasma contactors for use with electrodynamic tethers for power generation
(NASA-CR-182424) p 73 N88-16547

MATRA Espace, Paris-Velizy (France).

Robotic sensors and actuators for a service manipulator system. Volume 1: Executive summary
(MATRA-ESPT-DT/VT-87-120) p 97 N88-10361

Robotic sensors and actuators for a service manipulator system. Volume 2: Service Manipulator System (SMS) handbook
(MATRA-ESPT-DT/VT-87-227) p 97 N88-10362

Robotic sensors and actuators for a service manipulator system. Volume 3: phase A report and program plan
(MATRA-ESPT-DT/VT-87-228) p 97 N88-10363

Dynamic testing of a docking system
p 62 N88-19516

Utilization of robotics and telepresence for future in-orbit operations
p 93 N88-19527

MATRA Espace, Toulouse (France).

Preliminary study of a gravitational biology facility for Columbus: executive summary
(MATRA-ESPT-AS/VT209-255-87) p 145 N88-11205

Study on long term evolution towards European manned space flight. Volume 1: Executive summary
(MBB-R43-006-87-VOL-1) p 147 N88-17689

Assembly and servicing of a European Space Station
p 147 N88-19492

Utilization of MMS and EVA for the servicing of European Space Station
p 147 N88-19500

Promising concepts for ground to orbit experiment teleoperation
p 93 N88-19519

McDonnell Aircraft Co., St. Louis, Mo.

A human performance modeling approach to intelligent decision support systems
p 90 N88-11242

McDonnell-Douglas Astronautics Co., Houston, Tex.

Spacecraft material flammability testing and configurations
p 96 N88-12529

McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.

Space Station services and design features for users
(IAF PAPER 87-66) p 103 A88-11971

McDonnell-Douglas Astronautics Co., Huntsville, Ala.

A computer aided engineering tool for ECLS systems
(SAE PAPER 871423) p 98 A 88-21087

Intermodule ventilation studies for the Space Station
(SAE PAPER 871426) p 130 A88-21091

Space Station Mission Planning System (MPS) development study. Volume 1: Executive summary
(NASA-CR-179202) p 4 N88-10047

Space Station Mission Planning System (MPS) development study. Volume 2
(NASA-CR-179200) p 6 N88-10048

Space Station Mission Planning Study (MPS) development study. Volume 3: Software development plan
(NASA-CR-179203) p 4 N88-10049

McDonnell-Douglas Corp., St. Louis, Mo.

Knowledge-based simulation
p 102 N88-16404

Planning and scheduling for robotic assembly
p 90 N88-16416

Mercer Univ., Macon, Ga.

Self-shadowing effects on the thermal-structural response of orbiting trusses
p 32 A88-11734

Messerschmitt-Boelkow-Blohm/Entwicklungsring Nord, Bremen (West Germany).

EUREX D: An expert system for failure diagnosis and recovery in the TCS of the European retrievable carrier EURECA
p 140 N88-16395

Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).

Columbus feasibility studies. Volume 1: Requirements and system concept
(ETN-88-91073) p 146 N88-10799

Columbus feasibility studies. Volume 2: Element constituents, mechanical
(ETN-88-91074) p 146 N88-10800

Columbus feasibility studies. Volume 3: Avionics, systems
(ETN-88-91075) p 146 N88-10801

Columbus feasibility studies. Volume 5: Programmatics
(ETN-88-91076) p 147 N88-10802

Integrity control of carbon fiber reinforced plastics (CFRP) structural elements. Conclusion with respect to the control methodology of CFRP primary structures in manned space flight and the implications to the design, analysis and testing of CFRP structural elements, executive summary
(MBB-TN-455/87-DI4-90) p 97 N88-16826

Study on long term evolution towards European manned space flight. Volume 1: Executive summary
(MBB-R43-006-87-VOL-1) p 147 N88-17689

Rendezvous and docking verification and demonstration in orbit, executive summary
(MBB-351-16-88) p 61 N88-17710

Project management in astronautics. From Spacelab to Columbus
(MBB-UR-443-87) p 167 N88-17956

Columbus feasibility studies. Volume 4: Integration, test, and operations
(ETN-88-91076) p 167 N88-19814

Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).

Thermophysical Properties Measurement Facility (TPMF)
(ESA-CR(P)-2917) p 6 N88-10361

Mass of space platform electromagnetic (EMC) configuration
(ESA-CR(P)-2930) p 9 N88-16826

Michigan Technological Univ., Houghton.

Dynamics formulations for the real-time simulation of constrained motion
p 60 N88-14872

Michigan Univ., Ann Arbor.

Optimal time-free model transfers between elliptical orbits
(IAF PAPER 87-125) p 16 A88-16021

Translation and execution of distributed Ada programs: is it still Ada?
p 7 A88-21643

Full scale architectural simulation techniques for space stations
p 11 N88-19867

Mitre Corp., Houston, Tex.

An approach to design knowledge capture for the space station
p 7 A88-21642

Task level robot programming: integral part of evolution from teleoperation to autonomy
p 91 N88-17279

Moffett (H. Lee) Cancer Research Inst., Tampa, Fla.

Crew productivity issues in long-duration space flight
(AIAA PAPER 88-0464) p 114 A88-22330

Montana State Univ., Bozeman.

Consequences of bacterial resistance to disinfection by iodine in potable water
(SAE PAPER 871489) p 42 A88-21143

N

Naples Univ. (Italy).

Low density aerothermodynamics studies performed by means of the tethered satellite system
p 111 A88-16859

Downward-deployed tethered platforms for high enthalpy aerothermodynamic research
(AIAA PAPER 88-0668) p 114 A88-22514

National Academy of Sciences - National Research Council, Washington, D. C.

Medical effects of iodine disinfection products in spacecraft water
(SAE PAPER 871490) p 134 A88-21144

Space technology to meet future needs
(NASA-CR-181473) p 106 N88-10819

Critical issues in NASA information systems
(NASA-CR-182360) p 102 N88-16577

Report of the Committee on the Space Station of the National Research Council
(NASA-CR-181902) p 167 N88-17727

National Aeronautics and Space Administration, Washington, D.C.

Preparing for the future
p 109 A88-10395

Proprietary rights and commercial use of space stations
p 161 A88-13453

Spacecraft technology trends - A view from the past
(IAF PAPER 87-07) p 161 A88-15807

International Space Station operations: how dimensions - October 13, 1987
(IAF PAPER 87-13) p 122 A88-15810

NASA's Telerobotics R & D Program - Status and future directions
(IAF PAPER 87-04) p 92 A88-15816

An overview of the Office of Space Flight satellite servicing program plan
(IAF PAPER 87-35) p 122 A88-15825

Hubble Space Telescope servicing - Experience base for a new era
(IAF PAPER 87-36) p 139 A88-15826

Pathfinder technologies for solid new missions
(IAF PAPER 87-46) p 1 A88-15832

Technology - The basis for the past, the key to the future
(IAF PAPER 87-47) p 161 A88-15833

A research laboratory in space
(IAF PAPER 87-60) p 161 A88-15840

NASA and the Space Station - Current Status
(IAF PAPER 87-64) p 161 A88-15843

United States Space Station technical and programmatic interfaces
(IAF PAPER 87-65) p 162 A88-15844

The impact of launch vehicle constraints on U.S. Space Station design and operations
(IAF PAPER 87-72) p 2 A88-15848

Space Station information system - Concepts and international issues
(IAF PAPER 87-76) p 96 A88-15851

The United States Space Station revised baseline
(IAF PAPER 87-81) p 162 A88-15855

Space Station Program implications from the viewpoint of the Space Station Operations Task Force
(IAF PAPER 87-82) p 123 A88-15856

Science on the Space Station: The opportunity and the challenge - A NASA view
(IAF PAPER 87-92) p 96 A88-15863

Evolutionary Space Station infrastructure
(IAF PAPER 87-103) p 105 A88-15872

Past, present, and future activities in space power technology in the United States of America
(IAF PAPER 87-245) p 69 A88-15968

Artificial gravity - A countermeasure for zero gravity
(IAF PAPER 87-530) p 155 A88-16154

Long range planning at NASA
(IAF PAPER 87-670) p 163 A88-16243

Science on Space Station
p 2 A88-21586

International cooperation in the Space Station
p 142 A88-21673

OSSA's Telescience concept for the Space Station era
(AIAA PAPER 88-0120) p 112 A88-22080

Tether technology - Conference summary
(AIAA PAPER 88-0533) p 113 A88-22308

Comments on the early experimental validation session of the Second International Conference on Tethers in Space
(AIAA PAPER 88-0535) p 113 A88-22309

Outer atmospheric research
(AIAA PAPER 88-0668) p 9 A88-22512

In-space research, technology and engineering experiments and Space Station
p 3 A88-27780

Reusable space systems (Eugen Sanger Lecture, 1987)
p 125 A88-32479

Space station: Leadership for the future
(NASA-FAM-509/9-87) p 165 N88-10872

Communication satellite technology trends
p 76 N88-10888

A test-bed for space interferometry: Space Platform Interferometer (SPI)
p 5 N88-10840

The flight demonstration program and selection process
p 126 N88-10871

Space station systems: A bibliography with indexes (NASA-SP-7056(05))
p 5 N88-13382

Advancing automation and robotics technology for the space station and for the US economy. Submitted to the United States Congress May 15, 1987
(NASA-TM-89911) p 90 N88-15817

Advancing automation and robotics technology for the space station and for the US economy. Submitted to the United States Congress October 1, 1986
(NASA-TM-90180) p 89 N88-15818

Basic results of medical studies during prolonged manned flights on-board the Salyut-7/Soyuz-T orbital complex
(NASA-TT-20017) p 147 N88-16182

NASA Office of Space Flight (OSF) in-orbit servicing program
p 126 N88-19436

National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

Thermal response of integral multicomponent composites to a high-energy aerothermodynamic heating environment with surface temperature to 1650 K
p 10 A88-12591

Building intelligent systems - Artificial intelligence research at NASA Ames Research Center
p 92 A88-15350

Progress towards autonomous, intelligent systems
(IAF PAPER 87-01) p 93 A88-15823

257

Aeroassisted-vehicle design studies for a manned Mars mission
[IAF PAPER 87-433] p 50 A88-16093
Human factor design of habitable space facilities
[IAF PAPER 87-549] p 38 A88-16166
The opportunities for space biology research on the Space Station p 153 A88-20282
Accommodating life sciences on the Space Station
[SAE PAPER 871412] p 38 A88-21077
OSSA Space Station waste inventory
[SAE PAPER 871413] p 39 A88-21078
Stability of IRA-45 solid amine resin as a function of carbon dioxide absorption and steam desorption cycling
[SAE PAPER 871452] p 40 A88-21112
Water management requirements for animal and plant maintenance on the Space Station
[SAE PAPER 871469] p 41 A88-21125
Development of a thermal control coating for space suits
[SAE PAPER 871474] p 34 A88-21129
An innovative exercise method to simulate orbital EVA work - Applications to FLSS automatic controls
[SAE PAPER 871475] p 154 A88-21130
NASA Systems Autonomy Demonstration Program - A step toward Space Station automation
p 84 A88-21639
Theoretical considerations in designing operator interfaces for automated systems p 85 A88-21656
Cooperative human-machine fault diagnosis
p 85 A88-21659
Crew productivity issues in long-duration space flight
[AIAA PAPER 88-0444] p 154 A88-22330
Telescience testbedding for life science missions on the Space Station
[AIAA PAPER 88-0446] p 86 A88-22332
An operations concept for the Space Station based Astrometric Telescope Facility
[AIAA PAPER 88-0447] p 113 A88-22333
The opportunities for space biology research on the Space Station p 155 A88-29134
Need, utilization, and configuration of a large, multi-G centrifuge on the Space Station p 155 A88-29140
Aeroassisted-vehicle design studies for a manned Mars mission
[NASA-TM-100031] p 58 N88-11700
Performance considerations for the astrometric telescope facility on the phase 1 space station
[NASA-TM-100040] p 45 N88-14896
Microgravity Particle Research on the Space Station
[NASA-CP-2496] p 118 N88-15354
Astrophysics and the solar nebula
p 118 N88-15355
Atmospheric science p 5 N88-15357
Exobiology and life science p 118 N88-15358
Physics and chemistry p 118 N88-15359
MTX: An AI tool for model-based reasoning
p 9 N88-16372
KBS V and V as related to automation of space station subsystems. Rationale for a KBS lifecycle
p 9 N88-16375
Monitoring of space station life support systems with miniature mass spectrometry and artificial intelligence
p 45 N88-16376
Space vehicle approach velocity judgments under simulated visual space conditions
[NASA-TM-89437] p 156 N88-19094
Animal research on the Space Station
p 159 N88-19964
Workshop on Technology Development Issues for the Large Deployable Reflector (LDR)
[NASA-CP-2407] p 32 N88-20235

National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

Satellite servicing in the Space Station era
p 121 A88-15286
The Flight Telerobotic Servicer (FTS) - A focus for automation and robotics on the Space Station
[IAF PAPER 87-25] p 82 A88-15817
Technology advancements for servicing of future spacecraft systems
[IAF PAPER 87-36] p 122 A88-15826
Assembling, maintaining and servicing Space Station
[IAF PAPER 87-85] p 123 A88-15859
Space Station accommodation of attached payloads
[IAF PAPER 87-97] p 103 A88-15869
Remote sensing Earth's surface and atmosphere; Proceedings of Workshop X and the Topical Meeting of the 26th COSPAR Plenary Meeting, Toulouse, France, June 30-July 11, 1988 p 111 A88-17026
The effect of photoelectrons on beam-satellite potential differences during electron beam ejection
[AD-A190390] p 75 A88-20350
Assessment of external contamination for Space Station scientific payloads
[SAE PAPER 871476] p 130 A88-21131
The Solar Maximum Mission repair - Lessons learned
p 124 A88-21953
ENVIRONET database on vibroacoustics
[AIAA PAPER 88-0010A] p 99 A88-22011
Efficient spacecraft formationkeeping with consideration of ballistic coefficient control
[AIAA PAPER 88-0375] p 124 A88-22277
The GSFC Flight Support System for on-orbit satellite servicing
[AIAA PAPER 88-0448] p 124 A88-22334
Applications of tethered satellites to some problems of terrestrial physics
[AIAA PAPER 88-0689] p 114 A88-22515
Attitude Control Working Group report
p 57 N88-10099
Outgassing data for selecting spacecraft materials
[NASA-RP-1124] p 95 N88-10117
Fourteenth Space Simulation Conference: Testing for a Permanent Presence in Space
[NASA-CP-2446] p 5 N88-10829
Report from the WFP Working Group to the NASA Associate Administrator for Space Science and Applications
[NASA-TM-87919] p 150 N88-11402
The 1987 Get Away Special Experimenter's Symposium
[NASA-CP-2500] p 121 N88-17091
Assembly of user systems at Space Station
p 121 N88-19490
In-orbit and laboratory exchange of ORUs designed/not designed for servicing p 151 N88-19499
Multimission Modular Spacecraft (MMS): A serviceable design spacecraft p 6 N88-19501
Explorer Platform on-orbit servicing operations
p 121 N88-19526

National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.

Space Station ground data management system
p 96 A88-15282
The use of transputers in processing telemetry data
p 98 A88-15303
Space Station Program threat and vulnerability analysis
[AIAA PAPER 87-3062] p 104 A88-25210
EASE/ACCESS ground processing at Kennedy Space Center p 27 N88-10877
An AI approach for scheduling space-station payloads at Kennedy Space Center p 90 N88-16425

National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

Space Station viewing requirements
[SAE PAPER 861794] p 1 A88-10155
Crew factors in the design of the Space Station
p 151 A88-10947
Reliability models for Space Station power system
p 65 A88-11815
Incipient fault detection and power system protection for spaceborne systems p 66 A88-11826
Laser Docking System Radar flight experiment
p 47 A88-12814
Transitioning from Space Shuttle to Space Station on-orbit servicing p 121 A88-15290
Assembling, maintaining and servicing Space Station
[IAF PAPER 87-85] p 123 A88-15859
Development of a cooperative operational rendezvous plan for Eureca and other maneuvering Shuttle payloads
[IAF PAPER 87-218] p 123 A88-15948
Psychiatric components of a Health Maintenance Facility (HMF) on Space Station p 153 A88-20864
Environmental control and life support systems analysis for a Space Station life sciences animal experiment
[SAE PAPER 871417] p 39 A88-21081
Environmental control and life support system requirements and technology needs for advanced manned space missions
[SAE PAPER 871433] p 39 A88-21096
Thermoelectric integrated membrane evaporation subsystem testing
[SAE PAPER 871445] p 40 A88-21108
Recent developments in water quality monitoring for Space Station reclaimed wastewaters
[SAE PAPER 871447] p 40 A88-21107
Performance evaluation of SPE electrolyzer for Space Station life support
[SAE PAPER 871451] p 40 A88-21111
Life sciences biomedical research planning for Space Station
[SAE PAPER 871464] p 153 A88-21102
Biotechnology opportunities on Space Station
[SAE PAPER 871468] p 154 A88-21124
Electrochemically regenerable carbon dioxide/moisture control technology for an Advanced Extravehicular Mobility Unit
[SAE PAPER 871470] p 41 A88-21126
Development of a regenerable humidity and CO2 control system for an advanced EMU
[SAE PAPER 871471] p 41 A88-21127
Assessment of external contamination for Space Station scientific payloads
[SAE PAPER 871476] p 130 A88-21131
Review of water disinfection techniques
[SAE PAPER 871488] p 42 A88-21142
Medical effects of iodine disinfection products in spacecraft water
[SAE PAPER 871490] p 154 A88-21144
Treatment bed microbiological control
[SAE PAPER 871492] p 42 A88-21146
Inflight microbial analysis technology
[SAE PAPER 871493] p 42 A88-21147
New tools for EVA operations
[SAE PAPER 871499] p 124 A88-21150
Design of an ammonia two-phase Prototype Thermal Bus for Space Station
[SAE PAPER 871506] p 35 A88-21152
Test results of a shower water recovery system
[SAE PAPER 871512] p 42 A88-21158
Use of automation and robotics for the Space Station
p 84 A88-21632
NASA Systems Autonomy Demonstration Program - A step toward Space Station automation
p 84 A88-21639
An approach to design knowledge capture for the space station p 7 A88-21642
Space Station Active Thermal Control System modeling
[AIAA PAPER 88-0473] p 36 A88-22349
Processes in construction of failure management expert systems from device design information
p 86 A88-24230
Intelligent systems and robotics for an evolutionary Space Station p 86 A88-24230
A lunar laboratory p 106 A88-29196
Astronaut/EVA construction of Space Station
[AIAA PAPER 88-2459] p 125 A88-31382
Long-life assurance for Space Station - Is it an issue?
[AIAA PAPER 88-2489] p 43 A88-31398
Active vibration control in microgravity environment
p 55 A88-31565
High intensity 5 eV O-atom exposure facility for material degradation studies p 96 N88-10847
Space station contamination considerations
p 131 N88-10855
A monograph of the National Space Transportation System Office (NSTSO) integration activities conducted at the NASA Lyndon B. Johnson Space Center for the EASE/ACCESS payload flown on STS 61-B
p 27 N88-10878
A synopsis of the EVA training conducted on EASE/ACCESS for STS-61-B p 126 N88-10879
Overview of crew member energy expenditure during Shuttle Flight 61-B EASE/ACCESS task performance
p 156 N88-10882
Space station internal environmental and safety concerns p 198 N88-12527
Space suit extravehicular hazards protection development
[NASA-TM-100459] p 157 N88-12927
Airborne particulate matter in spacecraft
[NASA-CP-2499] p 157 N88-14623
National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987 Volume 1
[NASA-CR-172009-VOL-1] p 166 N88-14655
National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1987 Volume 2
[NASA-CR-172009-VOL-2] p 166 N88-14674
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems
[NASA-TM-89705] p 88 N88-15497
Advancing automation and robotics technology for the space station and for the US economy. Submitted to the United States Congress October 1, 1987
[NASA-TM-100777] p 69 N88-15916
Telerobotic controller development p 89 N88-16370
Integration of symbolic and algorithmic hardware and software for the automation of space station subsystems
p 89 N88-16373
Design knowledge capture for the space station
p 9 N88-17239
Expert system applications in spacecraft subsystem controllers p 90 N88-17254
TDAS: The Thermal Expert System (TEXSYS) data acquisition system p 102 N88-17258
Vision technology/algorithms for space robotics applications p 90 N88-17267
Telerobotic truss assembly p 91 N88-17272
Telerobot for space station p 91 N88-17274

Customer concerns regarding satellite servicing
p 129 N88-19503

National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
Capture-ejector satellites p 108 A88-11726
Preliminary conceptual design and weight of a one-megawatt space-based laser power station utilizing a solar-pumped iodine lasant p 65 A88-11816
Spaceborne optical disk controller development p 98 A88-12795
An amplitude modulated laser system for distance and displacement measurement p 47 A88-12813
Recent advances in structural dynamics of large space structures
[AF PAPER 87-01] p 11 A88-13835
SAFIRE - A novel high resolution cooled spectrometer for atmospheric research
[AF PAPER 87-137] p 109 A88-15894
The Aerosonest Flight Experiment
[AF PAPER 87-197] p 2 A88-15934
Manned Mars mission accomodation by the evolutionary Space Station
[AF PAPER 87-438] p 105 A88-16097
Low density aerothermodynamics studies performed by means of the tethered satellite system
p 111 A88-16859
Remote sensing Earth's surface and atmosphere; Proceedings of Workshop 9 and the Topical Meeting of the 26th COSPAR Plenary Meeting, Toulouse, France, June 30-July 11, 1986 p 111 A88-17026
AUTOPLAN - A PC-based automated mission planning tool p 7 A88-20486
Environmental control and life support systems analysis for a Space Station life sciences animal experiment
[SAE PAPER 871417] p 39 A88-21091
Hybrid honeycomb panel heat rejection system
[SAE PAPER 871419] p 34 A88-21093
Simulation and control of a Space Station air revitalization system
[SAE PAPER 871421] p 7 A88-21089
System architecture for teleorbotic servicing and assembly tasks p 95 A88-21649
Techniques for assessment of flexible space structure control performance
[AIAA PAPER 88-0677] p 52 A88-22507
Downward-deployed tethered platforms for high enthalpy aerothermodynamic research
[AIAA PAPER 88-0688] p 110 A88-22514
Information prioritization for control and automation of space operations p 86 A88-27355
Design of robust line-of-sight pointing control system for the SCOLE configuration p 54 A88-27367
Some experiences with the Eigensystem Realization Algorithm p 17 A88-29815
An application of MSC/NASTRAN in the interdisciplinary analysis of large space-based structures
p 17 A88-29819
NASA spaceborne optical disk recorder development
p 100 A88-29820
Large space structures - Structural concepts and materials
[SAE PAPER 872429] p 17 A88-30999
Structures and materials technology for Space Station
[AIAA PAPER 88-2446] p 17 A88-31377
Astronaut EVA construction of Space Station
[AIAA PAPER 88-2450] p 101 A88-31382
Steady state micro-g environment on Space Station
[AIAA PAPER 88-2462] p 4 A88-31385
Response of composite materials to the Space Station orbit environment
[AIAA PAPER 88-2476] p 99 A88-31390
Space Station - A focus for the development of structural dynamics scale model technology for large flexible space structures
[AIAA PAPER 88-2483] p 19 A88-31392
Dynamics and control characteristics of a reference Space Station configuration
[AIAA PAPER 88-2485] p 55 A88-31394
The impact of asymmetric physical properties on large space structures
[AIAA PAPER 88-2486] p 19 A88-31395
Orbit lifetime characteristics for Space Station
[AIAA PAPER 88-2490] p 66 A88-31399
Dynamics and control of a planar truss actuator
p 55 A88-31564
Structural tailoring and feedback control synthesis - An interdisciplinary approach
[AIAA PAPER 88-2206] p 21 A88-32177
A finite element method for time varying geometry in multibody structures
[AIAA PAPER 88-2234] p 21 A88-32197
Low authority/threshold control for large flexible structures
[AIAA PAPER 88-2070] p 53 A88-32226
Solution of structural analysis problems on a parallel computer
[AIAA PAPER 88-2287] p 22 A88-32240
The nonlinear behavior of a passive zero-spring-rate suspension system
[AIAA PAPER 88-2316] p 57 A88-32264
Three parallel computation methods for structural vibration analysis
[AIAA PAPER 88-2391] p 24 A88-32323
Spacecraft Systems Working Group report
p 165 N88-10091
Structures and Materials Working Group report
p 25 N88-10093
Recent advances in structural dynamics of large space structures
[NASA-TM-100513] p 26 N88-10867
Space Construction
[NASA-CP-2490] p 26 N88-10870
Access flight hardware design and development
p 26 N88-10873
Results of the ACCESS experiment
p 27 N88-10880
Design and assembly sequence analysis of option 3 for OETF reference space station
[NASA-TM-100503] p 105 N88-12369
Potential for on-orbit manufacture of large space structures using the pultrusion process
[NASA-TM-4016] p 28 N88-13388
Continuum modeling of large lattice structures: Status and projections
[NASA-TP-2767] p 28 N88-14115
An analysis of the effect of aeroassist maneuvers on orbital transfer vehicle performance
[NASA-TM-89117] p 150 N88-14116
Space station accommodations for lunar base elements: A study
[NASA-TM-100501] p 106 N88-14907
A space transportation system operations model
[NASA-TM-100481] p 6 N88-14999
Telerobotic research at NASA Langley Research Center p 91 N88-17289
Assessment of mixed fleet potential for space station launch and assembly
[NASA-TM-100550] p 107 N88-18608
Preliminary investigation of stability of a tin-stiffened slender strut
[NASA-TM-4039] p 31 N88-19568
Aeroassisted orbit transfer vehicle trajectory analysis
[NASA-TM-89138] p 62 N88-19575
Method of radiographic inspection of wooden members
[NASA-CASE-LAR-13726-1] p 149 N88-23983

National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
Space Station electric power system requirements and design p 63 A88-11782
Toluene stability Space Station Rankine power system
p 63 A88-11794
Advanced space solar dynamic power systems beyond IOC Space Station p 64 A88-11798
Solar concentrator advanced development project
p 64 A88-11799
Advanced solar receiver conceptual design study
p 64 A88-11800
Selection of high temperature thermal energy storage materials for advanced solar dynamic space power systems p 64 A88-11801
Fluoride salts and container materials for thermal energy storage applications in the temperature range 973 - 1400 K p 32 A88-11804
Impact of thermal energy storage properties on solar dynamic space power conversion system mass
p 64 A88-11805
Solar dynamic organic Rankine cycle heat rejection system simulation p 65 A88-11808
A novel photovoltaic power system which uses a large area concentrator mirror p 65 A88-11811
Development of an advanced photovoltaic concentrator system for space applications p 65 A88-11812
Performance characteristics of a combination solar photovoltaic heat engine energy converter
p 65 A88-11813
Control considerations for high frequency, resonant, power processing equipment used in large systems
p 47 A88-11829
EMC and power quality standards for 20-kHz power distribution p 68 A88-11830
An integrated approach to space station power system autonomous control p 67 A88-11853
LERC power system autonomy program 1990 demonstration p 67 A88-11861
Coaxial tube array space transmission line characterization p 75 A88-11865
A systems engineering approach to automated failure cause diagnosis in space power systems
p 68 A88-11870
Research opportunities in microgravity science and applications during Shuttle hiatus p 106 A88-13164
Optical measurements pertaining to Space Station solar dynamic power systems
[IAF PAPER 87-229] p 69 A88-15954
Space Station Electrical Power System
[IAF PAPER 87-234] p 69 A88-15958
Water-propellant resistojets for man-tended platforms
[IAF PAPER 87-259] p 78 A88-15975
Oxidation-resistant reflective surfaces for solar dynamic power generation in near earth orbit p 70 A88-19523
Space Station propulsion system technology
p 78 A88-21255
Space solar cell research - Problems and potential
p 70 A88-21605
Structural assessment of a Space Station solar dynamic heat receiver thermal energy storage canister
[AIAA PAPER 88-2447] p 72 A88-31396
Spacecraft 2000
[NASA-CP-2473] p 106 N88-10084
Spacecraft 2000 program overview
p 165 N88-10085
Space station assembly/servicing capabilities
p 125 N88-10100
Mechanical properties characterization of composite sandwich materials intended for space antenna applications
[NASA-TM-88850] p 27 N88-10121
Photovoltaic power modules for NASA's manned space station
[NASA-TM-100229] p 72 N88-11745
Space station propulsion
[NASA-TM-100216] p 79 N88-11746
A life test of a 22 Newton (5.0lf) hydrazine rocket
[NASA-TM-100232] p 79 N88-11750
An allotment planning concept and related computer software for planning the fixed satellite service at the 1988 space WARC
[NASA-TM-100264] p 165 N88-11944
Low Earth orbit environmental effects on the space station photovoltaic power generation systems
[NASA-TM-100230] p 73 N88-12429
Spacecraft Fire Safety
[NASA-CP-2476] p 156 N88-12527
Microgravity combustion fundamentals
p 79 N88-12528
Compatability of dispersion-strengthened platinum with resistojet propellants
[NASA-TP-2765] p 79 N88-12536
Communications payload concepts for geostationary facilities
[NASA-TM-100154] p 76 N88-13513
Status of 20 kHz space station power distribution technology
[NASA-TM-100781] p 73 N88-15838
Cryogenic Fluid Management Technology Workshop. Volume 1: Presentation material and discussion
[NASA-CP-10001] p 80 N88-15924
Simulation test beds for the space station electrical power system
[NASA-TM-100796] p 74 N88-17715
Magnetic emissions testing of the space station engineering model resistojet
[NASA-TM-100769] p 81 N88-17726
Oxidation and protection of fiberglass-epoxy composite masts for photovoltaic arrays in the low Earth orbital environment
[NASA-TM-100839] p 97 N88-18734
Compensation of reflector antenna surface distortion using an array feed
[NASA-TM-100265] p 77 N88-18805
Mast material test program (MAMATEP)
[NASA-TM-100821] p 31 N88-19582

National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
LERC power system autonomy program 1990 demonstration p 67 A88-11861
Automated load management for spacecraft power systems p 67 A88-11863
Research opportunities in microgravity science and applications during Shuttle hiatus p 106 A88-13164
OMV servicing missions from Space Station
p 121 A88-15291
Orbital Maneuvering Vehicle - New capability
[IAF PAPER 87-194] p 149 A88-15931
An advanced imaging space telescope concept
[IAF PAPER 87-460] p 110 A88-16113
A measurement of the angular distribution of 5 eV atomic oxygen scattered off a solid surface in earth orbit
p 130 A88-16666
Large space structures testing
[AAS PAPER 87-036] p 13 A88-16896
A computer aided engineering tool for ECLS systems
[SAE PAPER 871423] p 96 A88-21087
Intermodule ventilation studies for the Space Station
[SAE PAPER 871429] p 130 A88-21091

259

The Space Station air revitalization subsystem design concept
[SAE PAPER 871448] p 40 A88-21108
Environmental control and life support testing at the Marshall Space Flight Center
[SAE PAPER 871453] p 40 A88-21113
Technology demonstrator program for Space Station Environmental Control Life Support System
[SAE PAPER 871456] p 41 A88-21115
Assessment of external contamination for Space Station scientific payloads
[SAE PAPER 871476] p 130 A88-21131
Preliminary design of the Space Station internal thermal control system
[SAE PAPER 871505] p 35 A88-21151
Status of the Space Station water reclamation and management subsystem design concept
[SAE PAPER 871510] p 42 A88-21156
The use of computer graphic simulation in the development of on-orbit tele-robotic systems
p 95 A88-21646
An orbiting control station for free-flying teleoperators - Preliminary design methodology p 51 A88-21647
Advanced protein crystal growth flight hardware for the Space Station
[AIAA PAPER 88-0345] p 3 A88-22253
Tether Dynamics Simulation Workshop summary
[AIAA PAPER 88-0531] p 113 A88-22397
A telescope for high energy gamma-ray measurements in the Space Station era
[AIAA PAPER 88-0652] p 114 A88-22485
The X-ray large array. II - Implementation
[AIAA PAPER 88-0654] p 14 A88-22486
The tethered satellite electrodynamics experiment project
[AIAA PAPER 88-0690] p 114 A88-22516
An investigation of the damping phenomena in wire rope isolators p 21 A88-31597
Experimental study of damping of graphite epoxy composite material of the Space Telescope truss system
p 56 A88-31605
Analysis of oblique hypervelocity impact phenomena
[AIAA PAPER 88-2370] p 23 A88-32307
Solar-terrestrial research in the space station era
p 116 N88-10747
Marshall Space Flight Center's role in EASE/ACCESS mission management p 27 N88-10875
Research and development at the Marshall Space Flight Center Neutral Buoyancy Simulator p 5 N88-10878
Orbital transfer vehicle studies overview
p 150 N88-15931
Third Conference on Artificial Intelligence for Space Applications, part 1
[NASA-CP-2492-PT-1] p 89 N88-16380
Artificial intelligence and space power systems automation p 89 N88-16381
Emulating a flexible space structure: Modeling
[NASA-TM-100320] p 30 N88-16812
Development of a coupled expert system for the spacecraft attitude control problem p 61 N88-17223
Cost effective development of a national test bed
[NASA-TM-100321] p 21 N88-19585
Research and technology, 1987
[NASA-TM-100323] p 167 N88-20253

National Aeronautics and Space Administration. White Sands Test Facility, N. Mex.
Ignition and combustion of metals in oxygen
p 79 N88-12530

National Aerospace Lab., Amsterdam (Netherlands).
A DMAP for updating dynamic mathematical models with measured data
[NLR-MP-86027-U] p 26 N88-10367
A preliminary study of a fluid science laboratory for space station (Columbus). Part 4: Executive summary
[NLR-TR-87023-L-PT-4] p 79 N88-11072
Considerations concerning a thermal joint for a deployable or steerable battery radiator for the Columbus Polar Platform
[NLR-TR-86055-U] p 37 N88-11739
Study on long term evolution towards European manned space flight. Volume 1: Executive summary
[MBB-RA3-004/87-VOL-1] p 147 N88-17089
Definition of the EUROSIM simulation subsystem
p 149 N88-19532

National Aerospace Lab., Tokyo (Japan).
An overview of Japanese OELSS research activities
p 44 N88-12267
Formulation methods of rigid multibody systems for large space structures and some results of computer simulation
[NAL-TR-942] p 30 N88-17730

National Bureau of Standards, Gaithersburg, Md.
Techniques for fire detection p 158 N88-12521
NASA/NBS (National Aeronautics and Space Administration/National Bureau of Standards) standard reference model for Telerobot Control System Architecture (NASREM)
[PB88-124773] p 92 N88-17999
Spacecraft fire detection and extinguishment: A bibliography
[NASA-CR-180880] p 158 N88-18612

National Bureau of Standards, Washington, D.C.
Fire-related standards and testing
p 156 N88-12522

National Defense Univ., Washington, D. C.
America plans for space
[AD-A187465] p 167 N88-17713

National Research Council of Canada, Ottawa (Ontario).
Assembling, maintaining and servicing Space Station
[IAF PAPER 87-65] p 123 A88-15859

National Space Development Agency, Tokyo (Japan).
NASDA's new test facilities for satellites and rockets
p 147 N88-16951

Naval Submarine Medical Research Lab., Groton, Conn.
Fire-related medical science p 156 N88-12525

Nevada Univ., Las Vegas.
Attitude control of a three rotor gyrostat in the presence of uncertainty p 52 A88-22933
Flexible spacecraft maneuver - Inverse attitude control and modal stabilization p 53 A88-24291
Three axis rotational maneuver and vibration stabilization of elastic spacecraft p 54 A88-27364

New Mexico State Univ., Las Cruces.
High data rate modem simulation for the space station multiple access communications system
p 101 N88-14870

New Mexico State Univ., University Park.
Can space station software be specified through Ada?
p 9 N88-15622

Norfolk Public Schools, Va.
The NORSTAR Program: Space shuttle to space station p 167 N88-17710

North Carolina State Univ., Raleigh.
Natural control of flexible space structures
p 58 N88-12534

North Carolina Univ., Charlotte.
Dynamics of spacecraft control laboratory experiment (SCOLE) slew maneuvers
[NASA-CR-4098] p 57 N88-10082
Combined problem of slew maneuver control and vibration suppression
[NASA-CR-181537] p 59 N88-12817

Northeastern Univ., Boston, Mass.
Raman spectra of adsorbed layers on space shuttle and AOTV thermal protection system surface
p 132 N88-14890

O

Oak Ridge National Lab., Tenn.
Traction-drive seven degrees-of-freedom telerobot arm: A concept for manipulation in space
[DE87-010695] p 87 N88-10346

Oakwood Coll., Huntsville, Ala.
The feasibility of using TAE as the UIL for the space station and for other internal NASA tasks and projects
p 9 N88-15818

Office National d'Etudes et de Recherches Aerospatiales, Leclerc (France).
Optimal time free nodal transfers between elliptical orbits
[IAF PAPER 87-325] p 79 A88-16021

Old Dominion Univ., Norfolk, Va.
Self-shadowing effects on the thermal-structural response of orbiting trusses p 32 A88-11734
Assessment of the COFS/MAST I project
[NASA-CR-181366] p 25 N88-10340

P

Pace and Walla, Inc., Huntsville, Ala.
Personnel occupied woven envelope robot power
[NASA-CR-182367] p 88 N88-15196

Pennsylvania State Univ., University Park.
Information prioritization II: control and automation of space operations p 66 A88-27355

Perkin-Elmer Corp., Danbury, Conn.
An advanced imaging space telescope concept
[IAF PAPER 87-480] p 110 A88-16113

Photon Research Associates, Inc., Cambridge, Mass.
Large-angle slewing maneuvers for flexible spacecraft
[NASA-CR-4123] p 60 N88-16060

PRC Kentron, Inc., Hampton, Va.
An amplitude modulated laser system for distance and displacement measurement p 47 A88-12813
An application of MSC/NASTRAN in the interdisciplinary analysis of large space-based structures
p 17 A88-29819

Research, Inc., Houston, Tex.
An assessment of clinical chemical sensing technology for potential use on space station health maintenance facility
[NASA-CR-172013] p 156 N88-12926

Prism Consultants, Inc., Cleveland, Ohio.
Study of industry requirements that can be fulfilled by combustion experimentation aboard space station
[NASA-CR-180854] p 167 N88-19377

Princeton Synergetics, Inc., N.J.
The economics of satellite retrieval
[AIAA PAPER 88-0843] p 164 A88-27594

Purdue Univ., West Lafayette, Ind.
Convergence properties of modal costs for certain distributed parameter systems p 20 A88-31570

R

RADEX, Inc., Carlisle, Mass.
The effect of photoelectrons on boom-satellite potential differences during electron beam ejection
[AD-A190390] p 75 A88-20350
Analysis of geophysical data bases and models for spacecraft interactions
[AD-A194809] p 130 N88-13375

Radio Corp. of America, New York.
Telescience testbedding for life science missions on the Space Station
[AIAA PAPER 88-0446] p 94 A88-22332

RCA Government Services, Houston, Tex.
Life sciences biomedical research planning for Space Station
[SAE PAPER 871464] p 133 A88-21122

Reliance Electric Co., Worthington, Ohio.
Moving the factory into orbit p 165 N88-10844

Rensselaer Polytechnic Inst., Troy, N.Y.
Studies of the structural dynamic behavior of satellite antenna system
[AD-A195526] p 26 N88-14121

Research Triangle Inst., Research Triangle Park, N.C.
Potential applications of expert systems and operations research to space station logistics functions
[NASA-CR-180473] p 87 N88-12342

Rice Univ., Houston, Tex.
Optimal trajectories for aeroassisted, noncoplanar orbital transfer. II - LEO-to-LEO transfer
[IAF PAPER 87-328] p 49 A88-16024
Some considerations on measuring the Newtonian gravitational constant G in an orbiting laboratory
p 119 N88-15803

Rockwell International Corp., Canoga Park, Calif.
Advanced space solar dynamic power systems beyond IOC Space Station p 84 A88-11799
Radiator selection for Space Station Solar Dynamic Power Systems p 32 A88-11806
Optical measurements pertaining to Space Station solar dynamic power systems
[IAF PAPER 87-229] p 69 A88-15954
Space station propulsion technology: Space station propulsion system test bed test plan
[NASA-CR-179201] p 78 N88-10104
Space station reaction jet system requirements and interface definition study
[NASA-CR-180832] p 90 N88-12541
Space station propulsion technology
[NASA-CR-179260] p 60 N88-15835

Rockwell International Corp., Downey, Calif.
Environmental control and life support systems analysis for a Space Station life sciences animal experiment
[SAE PAPER 871417] p 39 A88-21081
An orbiting control station for free-flying teleoperators - Preliminary design methodology p 51 A88-21647
Orbital Spacecraft Consumables Resupply System (OSCRS). Volume 4: Extended study results
[NASA-CR-172012] p 126 N88-11686
Orbital Spacecraft Consumables Resupply System (OSCRS). Volume 2: Study results
[NASA-CR-172011] p 126 N88-11687
Orbital Spacecraft Consumables Resupply System (OSCRS). Volume 1: Executive summary
[NASA-CR-172010] p 126 N88-13368
Space station structures development
[NASA-CR-179261] p 30 N88-16792
Manipulator arm design for the Extravehicular Teleoperator Asset Robot (ETAR): Applications on the space station p 91 N88-17270
Crew interface with a telerobotic control station
p 91 N88-17273

Rome Univ. (Italy).
Astromag: A particle spectrometer for the Space Station
[PREPRINT-057] p 118 N88-14336

S

Saab-Space A.B., Linkoeping (Sweden).
Study of fault tolerant techniques for satellite data handling
[FTT/REP/0001/SAAB] p 101 N88-13660

San Jose State Univ., Calif.
Stability of IRA-45 solid amine resin as a function of carbon dioxide absorption and steam desorption cycling
[SAE PAPER 871452] p 40 A88-21112

Sanders Associates, Inc., Nashua, N. H.
Advanced solar receiver conceptual design study
p 64 A88-11830

Sandia National Labs., Albuquerque, N. Mex.
Estimating payload internal temperatures and radiator size for multimegawatt space platforms
[DE88-000244] p 37 N88-11738
The effect of maximum-allowable payload temperature on the mass of a multimegawatt space-based platform
[DE88-001921] p 37 N88-13381

Science Applications International Corp., Huntsville, Ala.
Optimization techniques applied to passive measures for in-orbit spacecraft survivability
[NASA-CR-178216] p 5 N88-12532

Science Applications International Corp., McLean, Va.
Space Station Program threat and vulnerability analysis
[AIAA PAPER 87-3082] p 104 A88-26210

Science Applications International Corp., Schaumberg, Ill.
Transitioning from Space Shuttle to Space Station on-orbit servicing p 121 A88-15290

Science Research Council, Chilton (England).
Study on long term evolution towards European manned space flight. Volume 1: Executive summary
[MSB-RA3-004/87-VOL-1] p 147 N88-17689

Science Research Council, Didcot (England).
SAFIRE - A novel high resolution cooled spectrometer for atmospheric research
[IAF PAPER 87-127] p 109 A88-15894

Sener S.A., Madrid (Spain).
Docking/Berthing Subsystem (DBS) Development part 1: Latching analysis
[ESA-CR(P)-2479] p 60 N88-15825
Coorbiting Platform Utilization Study (CPLUS) executive summary
[SN-WP-4000-DOC-8809/95-F] p 120 N88-16796
Multisurface control mechanism for a deployable antenna. Far Infrared and Submillimeter Space Telescope (FIRST) technology study
[RP-FA-0002] p 120 N88-16807
Robotics servicing experiment p 93 N88-19529

Signal Research Center, Inc., Des Plaines, Ill.
Catalytic processes for space station waste conversion
[NASA-CR-177423] p 44 N88-10491

Smith Advanced Technology, Inc., Huntsville, Ala.
Space station operating system study
[NASA-CR-179309] p 127 N88-19619

Smithsonian Astrophysical Observatory, Cambridge, Mass.
A telescope for high energy gamma-ray measurements in the Space Station era
[AIAA PAPER 88-0652] p 114 A88-22485
Analytical investigation of the dynamics of tethered constellations in Earth orbit (phase 2)
[NASA-CR-179218] p 117 N88-12533

Societe Anonyme Belge de Constructions Aeronautiques, Brussels.
Docking/Berthing Subsystem (DBS) Development part 1: Latching analysis
[ESA-CR(P)-2479] p 60 N88-15825

Societe Nationale Industrielle Aerospatiale, Cannes (France).
Analysis of RVD operations in manned space missions
p 61 N88-19494

Societe Nationale Industrielle Aerospatiale, Les Mureaux (France).
Rendezvous and Docking Verification (RVDV) and in-orbit demonstration, executive summary
[RVD-RVDV-FR-AS-01] p 127 N88-14120

Societe Nationale Industrielle Aerospatiale, Paris (France).
Metallurgy laboratory for Columbus, executive summary
[SNIAS-813-CA/TS] p 145 N88-10980

Southern California Inst. of Architecture, Santa Monica.
Space station group activities habitability module study: A synopsis p 6 N88-19886

Southern Univ., Baton Rouge, La.
Automatic antenna switching design for Extra Vehicular Activity (EVA) communication system
p 77 N88-14983

Southwest Research Inst., San Antonio, Tex.
Long-life assurance for Space Station - Is it an issue?
[AIAA PAPER 88-2489] p 43 A88-31398

Space Industries, Inc., Webster, Tex.
Water-propellant resistojets for man-tended platforms
[IAF PAPER 87-219] p 78 A88-15975

Stanford Univ., Calif.
Experiments in advanced control concepts for space robotics - An overview of the Stanford Aerospace Robotics Laboratory
[AAS PAPER 87-044] p 63 A88-16899
Modeling and control of large flexible vehicles in the atmosphere and space
[AD-A185368] p 27 N88-13377
Kinetic isolation tether experiment
[NASA-CR-182456] p 120 N88-16810

State Univ. of New York, Binghamton.
Treatment bed microbiological control
[SAE PAPER 871452] p 42 A88-21146

State Univ. of New York, Buffalo.
A model-free method for mass spectrometer response correction p 111 A88-19883
Low authority threshold control for large flexible structures
[AIAA PAPER 88-2270] p 22 A88-32226

Sterling Software, Palo Alto, Calif.
An innovative exercise method to simulate orbital EVA work - Applications to PLSS automatic controls
[SAE PAPER 871475] p 154 A88-21130

Stuttgart Univ. (West Germany).
A theoretical concept for static changers and shape changes in weightlessness p 157 N88-15365

Sundstrand Corp., Rockford, Ill.
Toluene stability Space Station Rankine power system
p 63 A88-11794
Integrated heat pipe thermal storage system performance evaluation p 32 A88-11803
Solar dynamic organic Rankine cycle heat rejection system simulation p 65 A88-11808

Sverdrup Technology, Inc., Cleveland, Ohio.
Structural assessment of a Space Station solar dynamic heat receiver thermal energy storage canister
[AIAA PAPER 88-2487] p 72 A88-31396
Component data base for space station resistojet auxiliary propulsion
[NASA-CR-180834] p 61 N88-17731

T

Taylor and Associates, Inc., Wrightwood, Calif.
Space station architectural elements model study. Space station human factors research review
p 102 N88-19864

Technische Hochschule, Darmstadt (West Germany).
On a knowledge based assisted system for highly autonomous control of experiment manipulators in the Man-Tended Free Flyer p 92 N88-19505
A knowledge-based approach for sensory-controlled assembly operations p 128 N88-19506
Remote manipulation in orbital construction, servicing and repair missions. Is one arm enough? A comparative evaluation of the performance features of robots with one or more arms p 93 N88-19509
A comparative survey of mathematical models for dynamic simulation of in-orbit manipulation operations
p 148 N88-19533

Technische Univ., Berlin (West Germany).
Definition and economic evaluation of Space Solar Power Systems (SSPS). part 1
[ILR-MITT-154-1(1987)] p 73 N88-16189
Definition and economic evaluation of Space Solar Power Systems (SSPS). part 2
[ILR-MITT-154-2(1987)] p 73 N88-16190

Tecnospazio S.p.A., Milan (Italy).
In-orbit automatic assembly of reticular structures
p 92 N88-19491

Teledyne Brown Engineering, Huntsville, Ala.
Polymer crystal growth facility concept for Space Station laboratory module p 1 A88-15314
Mission Peculiar Equipment Support Structure: A platform for space construction p 29 N88-10974
Microgravity and Materials Processing Facility study (MMPF): Requirements and Analyses of Commercial Operations (RACO) preliminary data release
[NASA-CR-179309] p 104 N88-18742

Tennessee Technological Univ., Cookeville.
Rapid toxicity detection in water quality control utilizing automated multispecies biomonitoring for permanent space stations p 44 N88-10948

Texas A&I Univ., Kingsville.
Dynamics, control and sensor issues pertinent to robotic hands for the EVA retriever system p 88 N88-14878

Texas A&M Univ., College Station.
Reliability models for Space Station power system
p 65 A88-11815

University Hospital, Copenhagen (Denmark).
Incipient fault detection and power system protection for spacestation systems p 66 A88-11828
Nondestructive construction error detection in large space structures
[AIAA PAPER 88-2486] p 19 A88-31393
Active vibration control in microgravity environment
p 58 A88-31585
The determination of nutritional requirements for Safe Haven Food Supply System (emergency/survival foods)
p 45 N88-14898
Active control of flexural vibrations in beams
p 59 N88-14966
Electrochemical processing of solid waste
[NASA-CR-182413] p 157 N88-15852

Texas A&M Univ., Galveston.
Power and charge dissipation from an electrodynamic tether p 73 N88-14928

Texas Christian Univ., Fort Worth.
NASA Systems Autonomy Demonstration Program - A step toward Space Station automation
p 64 A88-21639

Texas Univ., Arlington.
Lyapunov function gradient generated robust control in the absence of the nominal stabilizing control
p 54 A88-27404

Texas Univ., Austin.
The role of psychologists in future spaceflight
p 159 A88-10958
A parameter robust LQG design synthesis with applications to control of flexible structures
p 15 A88-27319

Texas Univ., El Paso.
Nondestructive construction error detection in large space structures
[AIAA PAPER 88-2486] p 19 A88-31393

Tokyo Univ. (Japan).
Results from a series of tethered rocket experiments
p 111 A88-18634
Adaptive control of Large Space Structure (LSS)
[ISAS-R-621] p 59 N88-11740

Toura Univ. (France).
Cardiovascular adaptation to zero-g during a long term flight (237 days) on board the Salyut 7 Soviet space station (1984) p 156 N88-19920
Cardiac and peripheral circulation assessement by ultrasound on 3 astronauts during two 7-day space flights (1982 Salyut 7 - 1985 STS 51G) p 158 N88-19921

Tri-State Univ., Angola, Ind.
Tether Elevator Crawler Systems (TECS)
p 119 N88-10631

TRW Defense and Space Systems Group, Huntsville, Ala.
OMV servicing missions from Space Station
p 121 A88-15291

TRW Defense and Space Systems Group, Redondo Beach, Calif.
Modeling of environmentally induced effects within satellites. Part 1: NASCAP modeling of satellites
p 58 N88-11721
Study of Plasma Motor Generator (PMG) tether system for orbit reboost
[NASA-CR-172016] p 117 N88-12501

TRW, Inc., Redondo Beach, Calif.
Advanced photovoltaic solar array design
p 63 A88-11793
OMV servicing missions from Space Station
p 121 A88-15291
Contamination control concepts for space station customer servicing p 131 N88-10990
SAMSS: An in-progress review of the Spacecraft Assembly, Maintenance, and Servicing Study
p 107 N88-15930

TRW Space Technology Labs., Redondo Beach, Calif.
Cost-effective orbit transfer modes for satellite retrieval and servicing p 61 N88-19489
Technology requirements for telerobotic satellite servicing in space p 93 N88-19536

U

Umpqua Research Co., Myrtle Creek, Ore.
Review of water disinfection techniques
[SAE PAPER 871488] p 42 A88-21142

United Technologies Research Center, East Hartford, Conn.
Carbon fiber reinforced glass matrix composites for space based applications
[AD-A184355] p 96 N88-12546

University Coll., London (England).
Covariant control of bilateral servos for in-orbit manipulation p 62 N88-19520

University Hospital, Copenhagen (Denmark).
Scientific objectives and functional requirements of life sciences in the Space Station p 158 N88-16264

University of South Florida, Tampa.
NASA Systems Autonomy Demonstration Program - A step toward Space Station automation
p 64 A89-21639
Utah Univ., Salt Lake City.
Medical effects of iodine disinfection products in spacecraft water
(SAE PAPER 871490) p 154 A88-21144

V

Virginia Polytechnic Inst. and State Univ., Blacksburg.
Computer modeling and simulation of a 20kHz ac distribution system for Space Station p 66 A89-11627
Maneuvering and vibration control of flexible spacecraft p 52 A88-22932
A survey of decentralized control techniques for large space structures p 16 A88-27358
Spillover stabilization of large space structures
(AIAA PAPER 88-2484) p 55 A89-21393
Dynamics and control of a planar truss actuator
p 55 A89-31564
Aeroassisted manned transfer vehicle (TAM) for advanced Mars Transportation NASA/USRA 1987 Senior Design Project
(NASA-CR-181478) p 106 N88-11736
New feedback design methodologies for large space structures: A multi-criterion optimization approach
p 59 N88-12535
Sensitivity of active vibration control to structural changes and model reduction p 30 N89-17683
Virginia Univ., Charlottesville.
Focus of attention in systems for visual monitoring of experiments p 112 A88-21658
Solution of structural analysis problems on a parallel computer
(AIAA PAPER 88-2287) p 22 A89-32240

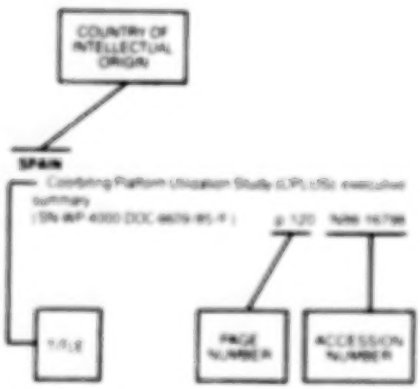
W

Washington Univ., Seattle.
Ram accelerator direct launch system for space cargo
(IAF PAPER 87-211) p 162 A88-15944
Inventory behavior at remote sites p 5 N88-14873
WEA, Cambridge, Mass.
Natural frequencies and structural integrity assessment of large space structures
(AD-A186139) p 29 N88-15001
Wave propagation experiments on 22-bay lattice
(AD-A186140) p 29 N88-15002
Wyle Labs., Inc., Huntsville, Ala.
Experiments to ensure Space Station live safety - A challenge
(AIAA PAPER 88-0540) p 155 A88-22405
Personnel occupied woven envelope robot power
(NASA-CR-182167) p 99 N88-15198

Y

Yankee Atomic Electric Co., Boston, Mass.
Information prioritization for control and automation of space operations p 96 A88-27355

Typical Foreign Technology Index Listing



Listings in this index are arranged alphabetically by country of intellectual origin. The title of the document is used to provide a brief description of the subject matter. The page number and the accession number are included in each entry to assist the user in locating the citation in the abstract section.

A

AUSTRALIA

National Space Engineering Symposium, 2nd, Sydney, Australia, Mar. 25-27, 1986. Preprints. Volumes 1 & 2 p 134 A88-15476

Commercial launch systems - The foreseeable future for Ausat p 161 A88-15480

Laser solar power satellites - A case study in technology forecasting p 88 A88-15482

Minibooms X-ray detector and spacecraft design study p 108 A88-15511

AUSTRIA

Solar plant growth facility (SPGF) - An approach toward future biological life support systems p 155 A88-29141

B

BRAZIL

Construction aspects of testbeds for attitude control systems simulation of artificial satellites (INPE-4283-PRE/1155) p 61 N88-19616

Simulation and tests of a satellite attitude and orbit control system. General considerations concerning an example case (INPE) and design of a servo rate table (INPE-4282-PRE/1154) p 62 N88-19572

BULGARIA

Electrostatic analyzers design for space investigation p 131 A88-29623

C

CANADA

Ross-Sterling engine - A high performance dynamic space power system p 63 A88-11787

The Canadian Mobile Servicing System for Space Station servicing p 82 A88-15269

Assembling, maintaining and servicing Space Station (IAF PAPER 87-95) p 123 A88-15859

Dynamics and control of the tethered satellite system in the presence of offsets (IAF PAPER 87-316) p 109 A88-16014

Dynamics and control during slewing maneuvers (IAF PAPER 87-353) p 49 A88-16043

On control of tethered satellite systems p 110 A88-16294

A near field test system for very large antennas p 13 A88-17599

Dynamics and control of the Tethered Satellite System in the presence of offsets p 112 A88-20036

A nonlinear general formulation for studying dynamics of the Space Station based MRMS with applications (AIAA PAPER 88-0674) p 52 A88-27504

Canada's Space Station Program p 142 A88-29980

Decentralized control of third generation spacecraft p 15 A88-27358

High-energy orbit refueling for orbital transfer vehicles p 150 A88-27867

Structural model verification with LQG theory (AIAA PAPER 88-2360) p 23 A88-32330

CHINA, PEOPLE'S REPUBLIC OF

Feedback control for attitude control system of the elastic vehicle p 46 A88-14536

On local state feedback and stability domain estimation of nonlinear large scale systems p 144 A88-29245

CZECHOSLOVAKIA

Plasmoid power station (IAF PAPER 87-250) p 69 A88-11969

D

DENMARK

Scientific objectives and functional requirements of life sciences in the Space Station p 154 A88-21570

Scientific objectives and functional requirements of life sciences in the Space Station p 158 N88-10264

E

ESTONIA

Observations of ocean and sea bottom relief from space p 143 A88-26099

F

FRANCE

Coordination of free flyers (IAF PAPER 87-16) p 108 A88-15811

Logistic flow for Columbus MTFF (IAF PAPER 87-39) p 123 A88-15829

European EVA requirements and space suit design (IAF PAPER 87-41) p 150 A88-15830

Evolution towards an autonomous European manned space infrastructure (IAF PAPER 87-67) p 138 A88-15846

One mission on board the MIR Space Station - The French Soviet project Aragatz (IAF PAPER 87-96) p 137 A88-15867

Operational utilization of the polar platforms (IAF PAPER 87-116) p 109 A88-15882

Space Station logistic support by Ariane (IAF PAPER 87-222) p 137 A88-15950

Interim Flight Opportunity (IFO) (IAF PAPER 87-379) p 138 A88-16054

Cosmonaut behaviour in orbital flight situation - Preliminary ethological analysis (IAF PAPER 87-526) p 152 A88-16151

Biomedical payload of the French Soviet long duration flight (IAF PAPER 87-541) p 152 A88-16159

Automatic control in space 1985 p 50 A88-16276

Solar sailing attitude control of large geostationary satellite p 50 A88-16280

Evaluation of control concepts for a large geostationary data relay satellite p 50 A88-16281

Modelling and simulation of distributed flexibility in a spaceborne manipulator p 83 A88-16309

Control techniques for rendez-vous and docking p 51 A88-16311

Control of in-orbit space manipulator p 51 A88-16312

New space priorities in the USSR p 136 A88-19624

Looking ahead for materials and processes. Proceedings of the Eighth SAMPE (European Chapter) International Conference, La Baule, France, May 19-21, 1987 p 94 A88-20701

Evolutive concept of an EVA space suit (SAE PAPER 871518) p 154 A88-21163

Aerospatiale studies for COF and ACF p 141 A88-21742

SPOT 1 - Earth observing satellite p 3 A88-21764

The Spacebus platforms (AIAA PAPER 88-0775) p 155 A88-27531

Prospects on future EVA communications (AIAA PAPER 88-0767) p 76 A88-27542

Identification and control of flexible structures p 54 A88-27764

Solar sails and the Anual satellite: Scientific applications and techniques p 136 A88-29664

Report on the scientific satellites of the European Space Agency (ESA SP-1090) p 116 N88-10061

Preliminary study of a gravitational biology facility for Columbus, executive summary (MATRA EPT-AS-VT209-255-N2) p 145 N88-10205

Robotic sensors and actuators for a service manipulator system. Volume 1: Executive summary (MATRA EPT-DT-VT167-120) p 87 N88-10341

Robotic sensors and actuators for a service manipulator system. Volume 2: Service Manipulator System (SMS) handbook (MATRA EPT-DT-VT167-227) p 87 N88-10342

Robotic sensors and actuators for a service manipulator system. Volume 3: phase A report and program plan (MATRA EPT-DT-VT167-228) p 87 N88-10343

A test-bed for space interferometry Space Platform interferometer (SPI) p 1 N88-10582

Metallurgy laboratory for Columbus, executive summary (SNIAS-813-CA-TS) p 145 N88-10980

Space Environment Technology (ISBN 2-85428-170-5) p 132 N88-11702

Spacecraft surface exposure to atomic oxygen in low Earth orbit p 96 N88-11715

External surface charging mechanisms p 132 N88-11719

Discharge phenomena p 132 N88-11721

Commercial Opportunities for Remote Sensing with Polar Platforms (ESA SP-269) p 117 N88-12131

Possible commercial use of the polar platforms p 161 N88-12132

Interoperability and integration of data relay satellite systems p 16 N88-12134

Legal protection of the Polar Platform's users p 161 N88-12135

The high performance solar array GSR3 (SNIAS-872-422-108) p 73 N88-13814

Rendezvous and Docking Verification (RVDV) and in-orbit demonstration, executive summary (RVD-RVDV-PR-AS-01) p 127 N88-14120

Technical aspects of future ocean colour remote sensing p 119 N88-16298

ESA Bulletin No. 25 (ISSN-0376-4265) p 146 N88-16767

Proceedings of the ESA Workshop on Co-Orbiting Platform Elements (COPE) (ESA SP-1093) p 146 N88-16777

Polar platform element of Space Station: Mission objectives, European priorities, candidate instrumentation and selection procedure p 119 N88-16779

Space station overview p 167 N88-16780

Use of Space Station for space science p 120 N88-16782

Microgravity payloads and missions for Space Station: Some issues affecting compatibility with other payloads p 120 N88-16783

The Columbus program, an overview p 146 N88-16784

263

Proceedings of the 1st European In-Orbit Operations Technology Symposium
[ESA-SP-272] p 126 N88-19484
Assembly and servicing of a European Space Station
p 147 N88-19492
Analysis of RVD operations in manned space missions
p 61 N88-19494
Utilization of SMS and EVA for the servicing of European Space Station p 147 N88-19500
Dynamic testing of a docking system
p 62 N88-19516
Promising concepts for ground-to-orbit experiment teleoperation p 93 N88-19518
Utilization of robotics and teleoperation for future in-orbit operations p 90 N88-19527
The European Space Agency's role in life sciences and research in space p 149 N88-19534
Life sciences in the framework of the ESA microgravity program and future flight opportunities
p 148 N88-19535
Cardiovascular adaptation to zero-g during a long term flight (237 days) on board the Salyut 7 Soviet space station (1984) p 158 N88-19920
Cardiac and peripheral circulation assessment by ultrasound on 3 astronauts during two 7-day space flights (1982 Salyut-7 - 1985 STS 51G) p 159 N88-19921
Antibiotic activity in space: results and hypothesis
p 159 N88-19952

G

GERMANY, FEDERAL REPUBLIC OF

The commercial use of space stations. The legal framework of trans-Atlantic cooperation: International Colloquium, Hanover, Federal Republic of Germany, June 10, 11, 1986, Reports
[DGLR BERICHT 86-02] p 160 A88-13443
Status of ongoing government-level negotiations on space stations p 132 A88-13444
Legal problems in the construction of space stations
p 133 A88-13449
ERM, the deployable mast for Columbus
p 11 A88-15279
Future European ground segment p 133 A88-15279
Rendezvous and docking technology for future European missions p 61 A88-15280
Columbus Space Segment definition
p 133 A88-15293
MTFF operational design features
p 134 A88-15295
Potentials of robotic operations on board the man-tended free-flyer
[IAF PAPER 87-17] p 62 A88-15913
Man tended free flyer interior equipment for manned and automated operation
[IAF PAPER 87-75] p 136 A88-15950
Long-term evolution toward European manned spaceflight
[IAF PAPER 87-79] p 136 A88-15953
Preparation of Space Station/Columbus utilization
[IAF PAPER 87-80] p 137 A88-15866
Solar- and nuclear electric propulsion for high energy orbits
[IAF PAPER 87-198] p 77 A88-15935
Solar thermal GTVs in comparison with electrical and chemical propulsion systems
[IAF PAPER 87-199] p 77 A88-15936
Collector and receiver designs for high temperature Brayton cycle for space application
[IAF PAPER 87-229] p 60 A88-15953
Aspects and possibilities of an integrated energy and media supply system on H2/O2 basis for manned space stations in the low earth orbit
[IAF PAPER 87-291] p 38 A88-15963
Stress and deformation analysis and tests of composite structures for space application
[IAF PAPER 87-312] p 12 A88-16011
Capabilities and special features concerning structural optimization of spacecraft structures
[IAF PAPER 87-330] p 12 A88-16018
Microgravity research and user support in the Space Station era - The Microgravity User Support Center
[IAF PAPER 87-390] p 110 A88-16061
The protein crystallization facility (PCF) for Eureca
[IAF PAPER 87-412] p 110 A88-16082
The DFS platform and its applications
[IAF PAPER 87-470] p 139 A88-16119
Radiation problems with the Space Station scenario and the necessary surveillance for astronauts
[IAF PAPER 87-542] p 129 A88-16160
Support of life science research in space by the DFVLR Microgravity User Support Center (MUSC)
[IAF PAPER 87-544] p 152 A88-16162
Costs and benefits of future heavy Space Freighters
[IAF PAPER 87-617] p 103 A88-16211
The dangers of space debris - New developments and discoveries p 130 A88-16398
The Columbus programme - European steps towards the considered development of near-earth space
p 136 A88-19835
The Soviet space flight project MIR
p 139 A88-20054
Columbus ECLSS
[SAE PAPER 871430] p 139 A88-21093
EVA for a European Scenario
[SAE PAPER 871432] p 123 A88-21095
Design and development of the life support subsystem of a laboratory model of the Botany Facility
[SAE PAPER 871519] p 43 A88-21164
Eureca - European user friendly retrievable carrier
p 139 A88-21251
European retrievable carrier Eureca servicing by Hermes p 139 A88-21256
A data base approach towards Columbus payload accomodation p 99 A88-21257
The Columbus system aspects p 140 A88-21556
The Resource Module p 140 A88-21559
Electrical power for Columbus - An important cross-element task p 140 A88-21560
Planning framework for high-technology space flight (CHR) p 142 A88-23516
Evolution of data management systems from Spacelab to Columbus
[MBB-UR-E 969-87] p 99 A88-23991
Decentralized/hierarchical control for large flexible spacecraft
[MBB-UR-967-87] p 52 A88-23992
Future European ground segment
[MBB-UR-E 976-87] p 142 A88-23993
Man Tended Free Flyer configurations and servicing scenarios
[MBB-UR-E 994-87] p 125 A88-23990
Man Tended Free Flyer utilization aspects
[MBB-UR-E 981-87] p 142 A88-23991
Orbital systems p 143 A88-26170
A 50 year scenario for the utilization of space to improve the quality of life on earth p 164 A88-27656
The space life sciences research and application in Europe p 143 A88-29106
Structural testing on the multi-axis simulator - An innovative simulation system for space vehicle structures
p 17 A88-29725
EPOS - A facility for simulating operations near spacecraft p 56 A88-32145
Aerothermodynamics - A key to new aerospace transport systems
[DGLR PAPER 87-077] p 4 A88-32477
Survey of parameter estimation methods in experimental modal analysis p 24 A88-32718
Study of a payload for Columbus Polar Platform Earth observation demonstration mission, executive summary
[ESA-CR(P)-2412] p 116 N88-10079
Preliminary study of a containerless processing facility for Columbus, executive summary
[ESA-ITT-AO/1-1.834/85F] p 96 N88-10203
Prephase A study of a crystallization laboratory for Columbus, executive summary
[ESA-ITT-AO/1-1666/85F] p 96 N88-10206
ISIS: Imaging Speckle Interferometer in Space
p 116 N88-10625
Thermophysical Properties Measurement Facility (TPMF)
[ESA-CR(P)-2417] p 8 N88-10991
X-band SAR for a European remote sensing payload
p 117 N88-12142
Progress in European CELSS activities
p 44 N88-12252
Allowable gravity-levels for Spacelab, Columbus and EURECA
[BF-R-66.525-2] p 132 N88-15084
A theoretical concept for state changers and shape changers in weightlessness p 157 N88-15365
Docking/Berthing Subsystem (DBS). Development part 1: Latching analysis
[ESA-CR(P)-2479] p 60 N88-15825
Safety philosophy, policy, and requirements for manned spaceflight. Volume 1: Executive summary
[HEG-0886/1036-VOL-1] p 157 N88-15826
Definition and economic evaluation of Space Solar Power Systems (SSPS), part 1
[ILR-MITT-184-1(1987)] p 73 N88-16189
Definition and economic evaluation of Space Solar Power Systems (SSPS), part 2
[ILR-MITT-184-2(1987)] p 73 N88-16190
EUREX D: An expert system for failure diagnosis and recovery in the TCS of the European retrievable carrier EURECA p 148 N88-16385
Columbus feasibility studies. Volume 1: Requirements and system concept
[ETN-88-91073] p 148 N88-16799
Columbus feasibility studies. Volume 2: Element constituents, mechanical
[ETN-88-91074] p 146 N88-16800
Columbus feasibility studies. Volume 3: Avionics, systems
[ETN-88-91075] p 146 N88-16801
Columbus feasibility studies. Volume 5: Programmatics
[ETN-88-91076] p 147 N88-16802
Multisurface control mechanism for a deployable antenna: Far Infrared and Submillimeter Space Telescope (FIRST) technology study
[RP-FA-0003] p 120 N88-16807
Model of space platform electromagnetic (EMC) configuration
[ESA-CR(P)-2580] p 9 N88-16809
Integrity control of carbon fiber reinforced plastics (CFRP) structural elements. Conclusion with respect to the control methodology of CFRP primary structures in manned space flight and the implications to the design, analysis and testing of CFRP structural elements, executive summary
[MBB-TR-R85/17-014/85] p 97 N88-16824
Study on long term evolution towards European manned space flight. Volume 1: Executive summary
[MBB-R&D-004-87-VOL-1] p 147 N88-17689
Rendezvous and docking verification and demonstration in orbit, executive summary
[MBB-303-16/86] p 61 N88-17719
Project management in astronautics: From Spacelab to Columbus
[MBB-URE-943-87] p 167 N88-17858
Columbus feasibility studies. Volume 4: Integration, test, and operations
[ETN-88-90176] p 147 N88-18614
Development of the Extendable and Retractable Mast (ERM). Design phase 2: Volume 1
[RP-2010-0000-DS/09] p 31 N88-18750
Man-Tended Free Flyer operational design features
p 129 N88-19485
Safe rendezvous approach to a space station by impulsive transfers and continuous thrust arcs
p 151 N88-19486
Mission profiles of the MTFF co-orbiting with the US Space Station p 6 N88-19487
Safe and fuel minimum reference trajectories for closed loop controlled approaches p 61 N88-19488
Automatic in-orbit payload deployment mechanisms, logistic operations and transport vehicle design compatibilities p 92 N88-19493
On a knowledge based assisted system for highly autonomous control of experiment manipulators in the Man-Tended Free Flyer p 92 N88-19505
A knowledge-based approach for sensory-controlled assembly operations p 129 N88-19508
Mobile robot activity model for autonomous free flying platforms p 92 N88-19507
Remote manipulation in orbital construction, servicing and repair missions. Is one arm enough? A comparative evaluation of the performance features of robots with one or more arms p 93 N88-19509
Treatment of unforeseen situations by online knowledge-based diagnostic systems
p 93 N88-19511
EPOS: European Proximity Operations Simulation
p 147 N88-19515
Columbus Simulation Facility (CSF)
p 148 N88-19522
Rendezvous and docking (RVD) verification and demonstration in-orbit p 62 N88-19531
A comparative survey of mathematical models for dynamic simulation of in-orbit manipulation operations
p 148 N88-19533
External payload servicing: Operational requirements and technology p 129 N88-19541
European activities in exobiological research in space
p 158 N88-19929
Radiation problems in manned space flight with a view to the Space Station p 132 N88-19934
Implications of shiftwork in space for human physiology experiments p 109 N88-19942
Microgravity User Support Center (MUSC) for EURECA, Spacelab and Columbus missions p 149 N88-19947

I

INDIA

Thermal design of the equipment platforms
[IAF PAPER 87-06] p 34 A88-15808
Deployment dynamics of accordion type of deployable solar arrays considering flexibility of closed control loops
[IAF PAPER 87-256] p 11 A88-15974

INTERNATIONAL ORGANIZATION

The applicable legal regime for international cooperation p 160 A88-13448

Advanced materials for ESA spacecraft
p 133 A88-13569
Simulation tools for the development of an autonomous rendezvous and docking system p 47 A88-13572
Enhanced Eureca configuration/operations
p 134 A88-15295
The Columbus system baseline and interfaces
p 134 A88-15787
The in-orbit technology demonstration programme of the European Space Agency
[IAF PAPER 87-03] p 135 A88-15803
Columbus, present programme status
[IAF PAPER 87-62] p 135 A88-15841
The Columbus space segment
[IAF PAPER 87-66] p 136 A88-15845
Trades and problems in the definition of the Columbus operation concept
[IAF PAPER 87-83] p 136 A88-15857
The potential of Columbus element utilisation
[IAF PAPER 87-94] p 137 A88-15865
Challenge '95 - The Ariane 5 Development Programme
[IAF PAPER 87-195] p 137 A88-15926
The use of advanced materials in space structure applications
[IAF PAPER 87-305] p 94 A88-16006
The Columbus Attached Pressurized Module - System and management aspects of international cooperation
p 139 A88-21252
Future in-orbit technology demonstrations
p 14 A88-21521
The Eureca concept and its importance in preparing the Columbus Programme p 140 A88-21524
The Columbus Programme p 140 A88-21555
Principles of operations cooperation between the United States and Europe p 141 A88-21564
Space science with Columbus p 141 A88-21567
Prospects and problems in microgravity fluid science
p 2 A88-21569
REPPRE-REPSIM-REPSTA - Programs for evaluating the availability and maintenance of space systems
p 125 A88-27779
Absorptive tethers - A first test in space
p 115 A88-27781
The Eureca space platform p 143 A88-29856

ISRAEL

A criterion for shape control robustness of space structures p 16 A88-29720

ITALY

Legal problems of the commercial use of space stations including proprietary rights p 150 A88-13452
Columbus Attached Pressurized Module configuration - APTP Pressurized Module configuration
p 134 A88-15298
EURECA - An expert system for the management of experiments to be performed on a free-flying platform
[IAF PAPER 87-29] p 135 A88-15821
Applicability of A.I. techniques to the Space Station, a study case - Development of an expert system for on-board fault management
[IAF PAPER 87-30] p 83 A88-15822
A new Italian proposal for a Space Station Assembly and Servicing Vehicle (ASMV)
[IAF PAPER 87-37] p 135 A88-15827
Tethered space elevator - Possible applications and demonstrative experiments
[IAF PAPER 87-49] p 109 A88-15834
Columbus pressurized modules. Maintenance and supply concepts - Approach and development for a Space Station long term support
[IAF PAPER 87-66] p 137 A88-15860
Trends to reduce development and operation costs for experiments of the future space laboratory
[IAF PAPER 87-100] p 105 A88-15871
Electrical current flow across the TSS - The core equipment and other related technical issues
[IAF PAPER 87-252] p 109 A88-15871
Numerical and numerical-analytical interfaces in structural thermal-dynamic interactive problems
[IAF PAPER 87-322] p 49 A88-16020
Columbus pressurized modules - A challenging opportunity for microgravity research and application
[IAF PAPER 87-375] p 137 A88-16050
Fault tolerant onboard implementation of control procedures in tethered satellite p 110 A88-16295
Tethered space system - A new facility for experimental rarefied gas dynamics p 111 A88-16858
Low density aerothermodynamics studies performed by means of the tethered satellite system
p 111 A88-16859
Feasibility study of a stabilizer fin for the tethered satellite system p 111 A88-16860
Thermal control definition of Columbus pressurized modules
[SAE PAPER 871483] p 139 A88-21138
Columbus pressurized module p 140 A88-21557
Columbus operation and utilization
p 141 A88-21560
Columbus utilization preparation - Status of ongoing studies p 141 A88-21565
Partnership, a key issue in the International Space Station cooperation p 142 A88-21575
Integrated control of large flexible structures
p 16 A88-29474
Columbus preparatory program. Payload element study on a technology demonstration mission, executive summary
[CS-RP-AI-016] p 145 N88-10080
Study of mobile communications payload for Columbus Polar Platforms
[ITS-TR-056A/86] p 76 N88-10220
Columbus pressurized module verification
p 145 N88-10842
Research on Electrodynamic Tether Effects (RETE) experiment Electrical Ground Support Equipment (EGSE)
[FSI-87-2] p 150 N88-13378
Mechanical design of the ac bracket package for the RETE experiment
[FSI-87-4] p 145 N88-13379
RETE experiment Assembly, Integration, and Verification (AIV) activities
[FSI-87-6] p 117 N88-13380
Ash-omag. A particle spectrometer for the Space Station
[PREPRINT 087] p 119 N88-14336
Expert system study for spacecraft management
[TL-2839-ISS-1] p 101 N88-15004
Columbus pressurized module utilization study, executive summary
[CS-RP-AI-027] p 146 N88-15005
Laboratory simulation of the electrodynamic interactions of a tethered satellite with an ionospheric plasma
[FSI-86-3] p 119 N88-15822
Analytical interactive approach for phenomena involving structures, thermal and control aspects. Volume 1 Theory
[ESA-CR(P)-2503-VOL-1] p 60 N88-16803
Analytical interactive approach for phenomena involving structures, thermal, and control aspects. Volume 2 Toward the solution
[ESA-CR(P)-2503-VOL-2] p 60 N88-16804
Analytical interactive approach for phenomena involving structures, thermal, and control aspects. Volume 3 Executive summary
[ESA-CR(P)-2503-VOL-3] p 60 N88-16805
In-orbit automatic assembly of reticular structures
p 92 N88-19491
Robotic intelligence issues for space manipulator monitoring, control programming p 92 N88-19504

J

JAPAN

A legal framework for Space Station activities
p 150 A88-13447
Conceptual design of the advanced technology platform
[IAF PAPER 87-02] p 138 A88-15802
Scanning laser radar system for rendezvous and docking in space
[IAF PAPER 87-03] p 49 A88-15838
JEM present project status
[IAF PAPER 87-63] p 135 A88-15842
Automation and robotics technology application to JEM
[IAF PAPER 87-74] p 136 A88-15849
Development scenario of H-II Orbiting Plane, HOPE
[IAF PAPER 87-210] p 48 A88-15943
Dynamic power generation for solar power satellites
[IAF PAPER 87-253] p 69 A88-15972
Research and development of the tension truss antenna
[IAF PAPER 87-317] p 12 A88-16015
Two-dimensionally deployable 'DHDF' truss
[IAF PAPER 87-319] p 12 A88-16017
A unified metric approach applied to dynamic formulation of complex space structures with nonlinear hinge forces and torques
[IAF PAPER 87-348] p 13 A88-16038
Mission function control applied to slow maneuver
[IAF PAPER 87-354] p 49 A88-16044
Reduced order models of a large flexible spacecraft
[IAF PAPER 87-356] p 13 A88-16046
Development of on-board satellite communications equipment in the Geostationary Platform era
[IAF PAPER 87-495] p 110 A88-16136
Modal damping measurement of MOS-1 Solar Array Paddle p 13 A88-16292
Vapor compression distiller and membrane technology for water revitalization p 38 A88-17072
Results from a series of tethered rocket experiments
p 111 A88-18634
Environmental control and life support system for Japanese Experiment Module
[SAE PAPER 871429] p 39 A88-21092
Experimental study for carbon dioxide removal system in Space Station
[SAE PAPER 871516] p 43 A88-21161
An experimental study of the Bosch and the Sabatier CO2 reduction processes
[SAE PAPER 871517] p 43 A88-21162
Formulation of rigid multibody systems in space
p 16 A88-21221
Toward new materials processing in space
p 2 A88-21572
Japan's contribution to the Space Station program
p 142 A88-21574
Root locus method for active control of flexible systems p 53 A88-24536
Proposal of adaptively controlled transmitting array for microwave power transmission in space
p 53 A88-25854
An experimental study on flexible spacecraft three-axis attitude control p 53 A88-26356
Development of a master-slave manipulator system for space use p 96 A88-26575
Numerical analysis of interaction of a high-voltage solar array with ionospheric plasma p 72 A88-27686
Geostationary tether satellite system and its application to communications systems p 115 A88-28974
Space life sciences in Japan p 193 A89-29107
The feasibility of Chlorella as the exchanger of CO2 for O2 and the food resources in the Space Station
p 43 A88-29136
Long-term strategy of space science in Japan
p 143 A88-29195
Analytical and experimental investigations for satellite antenna deployment mechanisms
[AIAA PAPER 88-2225] p 16 A88-32169
Vibration control of truss beam structures using axial force actuators
[AIAA PAPER 88-2273] p 22 A88-32229
Adaptive control of Large Space Structure (LSS)
[ISAS-R-621] p 98 N88-11740
Sunlight supply and gas exchange systems in microalgae bioreactor p 44 N88-12258
An overview of Japanese CELSS research activities
p 44 N88-12267
Solar converging method p 57 N88-12504
Formulation methods of rigid multibody systems for large space structures and some results of computer simulation
[NAL-TR-942] p 93 N88-17755
NASDA's new test facilities for satellites and rockets
p 147 N88-19951

N

NETHERLANDS

Mathematical models of flexible spacecraft dynamics - A survey of order reduction approaches
p 13 A88-16293
Control aspects of a European space manipulator system p 83 A88-16313
Fokker subsystem responsibilities in Columbus B phase studies p 141 A88-21561
Small reentry vehicles p 150 A88-26384
Design and verification of the FLECS test structure
p 54 A88-27779
A DMAP for updating dynamic mathematical models with measured data
[NLR-MP-86027-U] p 26 N88-10387
Space station based interferometry
p 115 N88-10529
A preliminary study of a fluid science laboratory for space station (Columbus). Part 4: Executive summary
[NLR-TR-87025-L-PT-4] p 79 N88-11072
Environmental interactions of solar generators in space p 72 N88-11730
Discharge prevention of geosynchronous orbit conductive thermal control materials and grounding systems p 76 N88-11732
Considerations concerning a thermal joint for a deployable or steerable battery radiator for the Columbus Polar Platform
[NLR-TR-86055-U] p 37 N88-11739
Payload configurations and serviceability
p 117 N88-12133
Thermal structural control modelling techniques
[FOK-TR-R-86-030] p 38 N88-15829
Applications of expert systems for satellite autonomy
p 90 N88-16443
Why mechanisms are critical to spacecraft performance p 90 N88-16737

265

Satellite assembly in geostationary orbit: A plug-and-socket concept p 127 N88-16750
Solar-like power systems under consideration by the United Nations p 74 N88-16773
An overview of the current Earth observation programs (Europe, USA, and Japan) p 167 N88-16779
Tethers: An outline of a new concept for Earth observation p 120 N88-16791
The ESA/Fokker servo end-effector subsystem: A robotic man-compatible servicing approach p 92 N88-19502
Motion emulation for in-orbit operations p 62 N88-19514
EUROSIM: A design concept for an in-orbit operations simulator p 140 N88-19517
Definition of the EUROSIM emulation subsystem p 148 N88-19532
Man-tended options for European space robotics p 94 N88-19538
Exobiology and botany facilities for EURECA p 148 N88-19558

NORWAY

AURO: A proposal for flying auroral imaging observatory on the Polar Platform in the Space Station/Columbus program p 119 N88-16268

P

POLAND

Educational and pedagogical importance of astronautics
[IAF PAPER 87-120] p 162 A88-16146
Solar thermodynamic power systems in space p 72 A88-26150

S

SPAIN

Columbus Platform Utilization Study (CPLUS): Executive summary
[SRI-87-4355-DOC-49210-65-9] p 150 N88-16708
Robotics servicing experiment p 93 N88-19529

SWEDEN

Central processing unit for fault tolerant computing in Columbus p 139 A88-21254
Study of fault tolerant techniques for satellite data handling
[FTT-/SQP-0001/SAAB] p 101 N88-13960

SWITZERLAND

Columbus takes shape - Europe's Space Station approaches decision time p 132 A88-13878
Large inflatable, space-rigidized antenna reflectors - Land mobile services development
[IAF PAPER 87-315] p 12 A88-16013
Space biology's inflight safety considerations
[IAF PAPER 87-510] p 153 A88-16182
Japan - Future space samurai? p 139 A88-16223
The incredibly versatile space tether p 114 A88-24494

U

U.S.S.R.

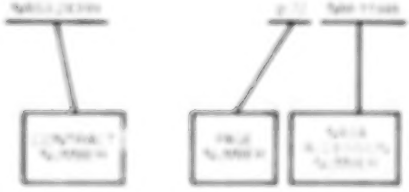
Theoretical principles of the optimal control of flexible spacecraft p 47 A88-10050
Stability of the steady motions of an electromagnetic tether system in orbit p 107 A88-11234
Motion perturbations of a dumbbell in a central Newtonian force field p 67 A88-11235
USSR export possibilities in the field of space hardware
[SAE PAPER 871342] p 133 A88-14388
Results of medical investigations conducted aboard the Salyut-6 - Soyuz orbital research complex p 135 A88-19850
Optimization of the energy systems of manned orbital stations - Mathematical modeling and selection of efficient structures p 64 A88-15664
Development experience of the attitude control system using single-axis control moment gyros for long-term orbiting space stations
[IAF PAPER 87-04] p 46 A88-15834
Men in space
[IAF PAPER 87-77] p 162 A88-15852
The beginning of the Mir station active operation
[IAF PAPER 87-94] p 136 A88-15858
Experience of the Salyut-7 propulsion system (PS) repair operations
[IAF PAPER 87-97] p 137 A88-15861
Problem of control arising during the implementation of scientific research program onboard the multipurpose orbital stations
[IAF PAPER 87-105] p 46 A88-15874
Sensitivity analysis and optimal design for large unrestrained structures
[IAF PAPER 87-321] p 12 A88-16019
The passive attitude motion of the orbital stations Salyut-6 and Salyut-7
[IAF PAPER 87-355] p 49 A88-16045
Thirty years of the space age p 162 A88-16074
Man in space flight
[IAF PAPER 87-527] p 162 A88-16155
Cosmonaut rescue equipment in manned space missions - Aspects of application
[IAF PAPER 87-576] p 153 A88-16167
Reconstruction of the vertical atmospheric temperature profile on the basis of refraction measurements from the Salyut-7 orbital station p 131 A88-27930
Intercosmos: An example of cooperation p 140 A88-28793
Construction of a full solution for an integrable case of the problem of the motion of two coupled bodies p 115 A88-29027
Construction of a full solution to the problem of the relative motion of a system of two bodies p 115 A88-29088
Synthesis of the flexible structures of complex systems p 15 A88-27148
Space near and far p 140 A88-27730
Deployable umbrella reflector antennas p 143 A88-27743
Optimization of the parameters of a solar photoelectric system exposed to cosmic rays p 72 A88-28250
Determination of cosmic-ray characteristics on Salyut-7 p 131 A88-28349
Working and space p 164 A88-29410
Stratospheric luminescence observed from the Salyut-7 station p 144 A88-33076
Rotation stability of a deformable flight vehicle p 104 A88-30115
USSR report: Space
[JPRS-USP-87-003] p 144 N88-13050
Raspov commentary on Mir station, first morning p 164 N88-13061
X-ray astronomy instruments to operate on Mir station p 165 N88-13062
Study of certain biological characteristics of bacteria during the French-Soviet CYTOS-2 space experiment p 141 N88-12917
JPRS report: Science and technology, USSR: Space
[JPRS-USP-87-008] p 145 N88-16063
Gyrostabilizer system of Kvant module p 60 N88-16099
Basic results of medical studies during prolonged manned flights on board the Salyut-7/Soyuz-T orbital complex
[NASA-TT-20217] p 147 N88-16162
Ballistocardiography in weightlessness research p 46 N88-19080
Medlab: A project of a medical laboratory in space p 159 N88-19946

UNITED KINGDOM

Has manned space flight a future? p 159 A88-10950
Looking to year 2001 p 104 A88-13074
Listening to the cosmonauts p 75 A88-13975
Large flexible solar arrays p 11 A88-15277
A Pallet-based space program for Australia p 122 A88-15521
Environmental constraints for Polar Platform design
[IAF PAPER 87-09] p 108 A88-15809
European Polar Platform operations and logistics
[IAF PAPER 87-11] p 135 A88-15812
On-orbit servicing and cost effectiveness of Columbus polar platform concepts
[IAF PAPER 87-42] p 103 A88-15831
Possibilities for a European evolutionary space infrastructure
[IAF PAPER 87-98] p 105 A88-15847
The utilization of the Columbus Polar Platform
[IAF PAPER 87-99] p 162 A88-15869
Configuration drivers for the European Polar Platform
[IAF PAPER 87-104] p 137 A88-15873
SAFIRE - A novel high resolution cooled spectrometer for atmospheric research
[IAF PAPER 87-137] p 109 A88-15894
Concept studies for a laser powered Orbital Transfer Vehicle
[IAF PAPER 87-200] p 77 A88-15937
Past, present and future activities in space power technology in the UK
[IAF PAPER 87-243] p 83 A88-15964
Angular momentum management for LEO platforms
[IAF PAPER 87-349] p 40 A88-16030
Application of adaptive observers to the control of flexible spacecraft p 50 A88-16096
Mir - Soviet base in space p 139 A88-16078
Soyuz enters third decade p 138 A88-16750
Radiation characteristics of offset cylindrical reflector antennas p 34 A88-17566
Endurance record broken p 138 A88-18630
Soviet shuttle for Space Station role p 138 A88-18700
Robots - Autonomous space workers p 84 A88-19866
Damming the data stream from space p 98 A88-19869
Earth observation from the Space Station p 110 A88-21557
A packetised remote visual access data system for Space Station interactive payload operations p 99 A88-21253
Strengthening graphite-epoxy composites p 91 A88-21554
The Columbus polar platform p 140 A88-21558
Earth observation and the Space Station p 112 A88-21560
The structure of VLF waves produced by a tethered satellite system p 114 A88-23924
Debris hazard poses future threat p 131 A88-24946
Swath altimetry of oceans and terrain p 115 A88-27838
Cosmonauts observe supernova p 144 A88-30169
The Soviet cosmonaut team, 1976-1987 p 144 A88-30185
Simple analysis of Space Station downtimes p 150 A88-30189
A composite structural system for a large collapsible space antenna p 19 A88-31403
Teleoperation and control study
[SAE TP-0250] p 67 N88-10489
Confidentiality of data p 145 N88-12136
Commercial perspective of an imaging spectrometer development program p 165 N88-12138
Study of large solar arrays (SOLA), phase 2B
[BAE SS-1109] p 74 N88-17108
Study of Large Solar Arrays (SOLA): Phase 2B. Amplifying information to final report (SS-1109)
[BAE SS-1110] p 74 N88-17880
Covariant control of bilateral servos for in-orbit manipulation p 62 N88-19520
EVA: the technological challenge p 128 N88-19535
A teleoperated manipulator system concept for unmanned platforms p 94 N88-19537

266

Typical Contract Number Index Listing



Listings in this index are arranged alphanumerically by contract number. Under each contract number, the accession numbers denoting documents that have been produced as a result of research done under that contract are arranged in ascending order with the AIAA accession numbers appearing first. The accession number denotes the number by which the citation is identified in the abstract section. Preceding the accession number is the page number on which the citation may be found.

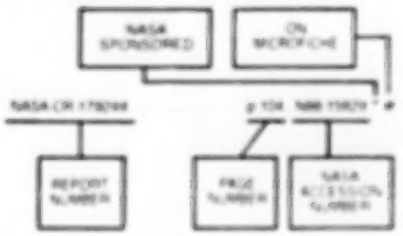
AF PROJ 2302 p. 27 N88-13477
AF PROJ 2304 p. 27 N88-12794
AF-AFOSR-3106-85 p. 30 N88-16019
AF-AFOSR-0366-83 p. 29 N88-14121
AF-AFOSR-82-0062 p. 27 N88-13477
AF-AFOSR-83-0361 p. 52 A88-22609
AF-AFOSR-84-0371 p. 15 A88-27319
AF-AFOSR-85-0220 p. 22 A88-32226
AF-AFOSR-85-0353 p. 27 N88-12794
AF-AFOSR-87-0231 p. 29 A88-32339
DAAG29-84-K-0022 p. 190 A88-13443
CEC 1355.3757.M0001-1-2102 p. 15 A88-27356
CNES-83-0768 p. 83 A88-16309
CNES-83-721 p. 83 A88-16309
CNES-840-85 p. 62 N88-10016
CNES-840-86 p. 62 N88-14016
DA PROJ 4B1-62731-AT-41 p. 31 N88-14883
DE-AC04-76DP-00789 p. 27 N88-11736
p. 37 N88-13381
DE-AC05-84OR-21400 p. 64 A88-11802
p. 87 N88-10306
DSS-01ST-38100-6-4158 p. 23 A88-32300
ESA 4442/-80 Nl, AA(SC) p. 97 N88-16824
ESA 4803/-81 Nl, JS(SC) p. 74 N88-17106
p. 74 N88-17480
ESA 5505/-83 Nl, PB p. 12 A88-16013
ESA 5665/-83 p. 50 A88-16296
ESA 5739/-83 Nl, AN(SC) p. 87 N88-10341
p. 87 N88-10342
p. 87 N88-10343
ESA 6001/-84 Nl, SI p. 115 A88-27839
ESA 6029/-84 p. 101 N88-15004
ESA 6116/-84 p. 87 N88-10469
ESA 6284/-85 Nl, PB p. 12 A88-16013
ESA 6482/-85 Nl, AN p. 148 N88-19533
ESA 6492/-85 Nl, AN(SC) p. 61 N88-17719
ESA 6493/-85 Nl p. 127 N88-14120
ESA 6501/-85 F Nl(SC) p. 145 N88-10205
ESA 6506/-85 F Nl(SC) p. 79 N88-11072
ESA 6536/-85 F Nl(SC) p. 95 N88-10201
ESA 6536/-85 Nl, MA(SC) p. 9 N88-16809
ESA 6606/-85 F RO(SC) p. 76 N88-10220
ESA 6614/-85 Nl, PP(SC) p. 145 N88-10080
ESA 6615/-85 F HE W(SC) p. 8 N88-11081
ESA 6616/-85 F HE W(SC) p. 95 N88-10259
ESA 6625/-85 F Nl, SC p. 145 N88-10080
ESA 6669/-86 Nl, PP(SC) p. 147 N88-11049
ESA 6726/-86 F Nl, ISC) p. 132 N88-15084
ESTEC 5158/-82 Nl, PB(SC) p. 39 N88-15828
ESTEC 5485/-83 Nl, PB(SC) p. 60 N88-16803
p. 60 N88-16804
ESTEC 5676-83 Nl, AN(SC) p. 31 N88-16750
ESTEC 5866-84 Nl, AN(SC) p. 120 N88-16807
ESTEC 6074-84 Nl, PB p. 101 N88-13860
ESTEC 6439-85 Nl, AN(SC) p. 60 N88-15825
ESTEC 6544-85 Nl, PP p. 139 A88-21706
ESTEC 6612-86 Nl, JS p. 116 N88-10079
ESTEC 6668-86 Nl, PP p. 136 A88-15846
ESTEC 6734-86 Nl, MA(SC) p. 157 N88-15826
F19701-86-C-0032 p. 127 N88-15800
F19628-83-C-0105 p. 75 A88-20050
p. 100 N88-13375
F19628-86-K-0019 p. 95 A88-22320
F33602-86-C-0262 p. 81 A88-12571
F33615-82-C-3222 p. 20 A88-31580
p. 20 A88-31586
F33615-82-K-1106 p. 83 A88-16369
F33615-85-C-1106 p. 83 A88-16369
F33615-86-C-3233 p. 21 A88-32225
p. 17 A88-32341
F33615-86-K-3611 p. 15 A88-27325
F49620-82-C-0009Z p. 83 A88-16369
F49620-82-C-0035 p. 72 A88-20317
F49620-83-C-0087 p. 14 A88-19632
F49620-85-C-0011 p. 14 A88-27402
F49620-85-C-0149 p. 29 N88-15021
p. 29 N88-15022
F49620-86-C-0030 p. 16 A88-27407
p. 29 N88-15003
F49620-86-K-0001B p. 31 A88-22501
F49620-87-C-0074 p. 21 A88-32177
JPL 954415 p. 43 A88-16029
JPL 954416 p. 76 A88-16021
JPL 957358 p. 83 A88-11701
JPL 957851 p. 14 A88-27404
MDA903-86-K-0037 p. 83 A88-16369
MIPR #J1NPD-7-04099 p. 31 N88-14883
NAGW-21 p. 24 A88-32339
p. 17 A88-32362
NAG8-235 p. 111 A88-19634
NAG8-812 p. 130 A88-16866
NAG8-847 p. 68 N88-15196
p. 89 N88-16409
NAG1-126 p. 59 N88-13378
NAG1-225 p. 52 A88-22402
NAG1-383 p. 18 A88-31383
NAG1-535 p. 17 N88-10362
p. 59 N88-12817
NAG1-551 p. 37 N88-15823
NAG1-567 p. 8 A88-32190
NAG1-570 p. 55 A88-31564
NAG1-603 p. 55 A88-31393
NAG1-612 p. 24 A88-32325
NAG1-642 p. 20 A88-31570
NAG1-678 p. 97 N88-15382
p. 97 N88-16879
NAG1-745 p. 162 A88-15864
NAG2-137 p. 159 A88-10956
NAG2-350 p. 7 A88-21643
NAG3-352 p. 86 N88-10836
NAG3-419 p. 77 N88-16805
NAG3-551 p. 66 A88-11827
NAG3-618 p. 74 N88-13030
NAG5-325 p. 112 A88-21531
NAG5-338 p. 112 A88-21531
NAG5-597 p. 112 A88-21658
NAG5-780 p. 68 N88-13808
NAG5-949 p. 55 N88-13807
NAG8-081 p. 27 N88-12343
NAG8-532 p. 21 A88-21597
NAG8-546 p. 151 N88-20005
NAG8-551 p. 115 A88-21680
NAG8-689 p. 60 N88-13648
NAG9-132 p. 69 A88-15970
p. 73 N88-16547
NAG9-192 p. 157 N88-15852
NASA ORDER A-21176 p. 10 N88-15865
NASA ORDER C-32000-J p. 158 N88-16612
NASA ORDER W-30746 p. 37 N88-12747
NAS8-30511 p. 167 N88-17727
NAS8-3521 p. 116 N88-14123
NAS8-4000 p. 156 N88-10819
NAS8-4066 p. 121 N88-15585
NAS8-41124 p. 102 N88-16527
NAS8-4307 p. 147 N88-16182
p. 94 A88-13239
p. 31 A88-18561
p. 16 A88-31369
p. 52 A88-22603
p. 25 N88-11340
p. 60 N88-16360
p. 16 A88-27359
p. 58 N88-11735
p. 97 N88-15527
p. 7 A88-20466
p. 107 N88-13580
p. 67 N88-12392
p. 28 N88-13554
p. 44 N88-14625
p. 45 N88-14626
p. 44 N88-10497
p. 60 N88-15006
p. 87 N88-17731
p. 167 N88-18277
p. 163 A88-16271
p. 164 A88-27384
p. 77 N88-16764
p. 72 N88-11499
p. 60 N88-12541
p. 33 A88-11627
p. 35 A88-21155
p. 32 A88-11603
p. 70 N88-16293
p. 79 N88-16369
p. 64 A88-11736
p. 155 A88-22405
p. 102 N88-16427
p. 62 A88-10816
p. 58 A88-32178
p. 22 A88-32259
p. 6 N88-13477
p. 29 N88-16367
p. 26 N88-13868
p. 93 N88-16536
p. 104 N88-17731
p. 66 N88-17722
p. 66 N88-17723
p. 66 N88-17724
p. 104 N88-10829
p. 66 N88-10827
p. 104 N88-10871
p. 61 N88-17717
p. 127 N88-15895
p. 67 N88-12105
p. 116 N88-11481
p. 108 A88-15814
p. 150 N88-16609
p. 150 N88-16610
p. 1 A88-15314
p. 104 N88-16782
p. 56 A88-31605
p. 130 A88-16866
p. 35 A88-21153
p. 130 A88-21091
p. 18 N88-10104
p. 60 N88-15835
p. 30 N88-16792
p. 16 A88-31368
p. 18 A88-31397
p. 25 N88-10072
p. 50 N88-17668
p. 79 N88-11753
p. 127 N88-16619
p. 118 N88-14113
p. 118 N88-14114
p. 117 N88-12533
p. 127 N88-14116
p. 116 N88-10828
p. 91 N88-17270
p. 105 A88-22049
p. 4 A88-10047
p. 4 N88-10048
p. 4 N88-10049
p. 5 N88-12532
p. 62 A88-21146
p. 35 A88-22349

CONTRACT

267

NAS9-16023	p 75	A89-16378
NAS9-16042	p 111	A89-19863
NAS9-16091	p 37	N89-12747
NAS9-17103	p 130	A89-21131
NAS9-17200	p 157	N89-14623
NAS9-17230	p 4	N89-10071
NAS9-17237	p 41	A89-21126
NAS9-17327	p 36	A89-22343
NAS9-17340	p 42	A89-21143
NAS9-17367	p 103	A89-10870
NAS9-17495	p 36	A89-22345
NAS9-17560	p 25	N89-10103
	p 58	N89-13866
NAS9-17584	p 126	N89-11686
	p 126	N89-11687
	p 126	N89-13368
NAS9-17585	p 126	N89-11741
NAS9-17586	p 122	A89-15292
NAS9-17594	p 156	N89-12826
NAS9-17666	p 117	N89-11737
NAS9-17751	p 117	N89-12501
NCC2-389	p 120	N89-10910
NCC3-90	p 34	A89-15860
NCC9-17	p 43	A89-31398
NGT-21-002-080	p 107	N89-10076
NGT-33-183-801	p 22	A89-32228
NGT-44-001-800	p 166	N89-14855
	p 160	N89-14874
NIVR-1050	p 26	N89-10387
NSERC-G-1547	p 49	A89-16043
NSF ECS-82-09615	p 124	A89-21637
NSF ECS-85-09145	p 11	A89-13652
NSF MEA-83-51907	p 22	A89-32228
NSG-1414	p 52	A89-22505
	p 29	N89-11830
NSG-1490	p 55	A89-28043
N00014-83-C-0649	p 124	A89-21637
N00014-84-C-0149	p 59	N89-13376
N00014-85-C-0274	p 124	A89-21637
N00014-85-C-0332	p 97	N89-12546
N00014-86-C-2004	p 65	AP3-11917
W-31-109-ENG-38	p 71	AUA-22691
W-7405-ENG-48	p 89	N89-11497
199-30-21	p 43	N89-14896
199-60-00-00-72	p 157	N89-14623
474-46-10	p 97	N89-10734
474-46-30	p 74	N89-17715
480-21-02	p 167	N89-19377
480-43-02	p 77	N89-16794
481-01-02	p 79	N89-11746
481-02-02	p 80	N89-12541
	p 81	N89-17728
	p 81	N89-17731
481-50-02	p 74	N89-18058
481-54-02	p 73	N89-15838
481-69-00-00-72	p 157	N89-12927
482-52-01	p 158	N89-19094
482-55-52	p 72	N89-11745
	p 31	N89-19592
483-32-03	p 107	N89-19638
483-32-13-01	p 156	N89-14807
505-33-52	p 26	N89-10121
505-40-41	p 58	N89-11702
506-42-31	p 79	N89-11700
	p 79	N89-12536
506-43-41-02	p 26	N89-10870
	p 26	N89-14115
	p 31	N89-19588
506-43-51-02	p 26	N89-10867
506-46-11-01	p 57	N89-10082
	p 58	N89-11735
506-46-21-01	p 150	N89-14116
	p 82	N89-19575
506-46-21	p 80	N89-10924
506-49-11-01	p 28	N89-13388
506-49-11-03	p 9	N89-14998
506-49-21-01	p 31	N89-10941
506-49-21	p 106	N89-10994
506-49-39	p 158	N89-12520
506-49-51-01	p 126	N89-13368
	p 107	N89-19580
506-62-21	p 32	N89-20235
506-64-31-05	p 44	N89-10491
505-01-21-01	p 60	N89-16090
643-10-01	p 165	1989-11944
650-60-20	p 77	N89-16805
650-60-28	p 76	N89-15513
805-19-50-01	p 118	N89-15354

Typical Report Number Index Listing



Listings in this index are arranged alphanumerically by report number. The page number indicates the page on which the citation is located. The accession number denotes the number by which the citation is identified. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

A-85394 p. 32 N86-20235 * #
A-87130 p. 158 N88-19034 * #
A-87208 p. 58 N88-11700 * #
A-87361 p. 118 N88-15354 * #
A-88021 p. 45 N88-14846 * #

AAS PAPER 87-021 p. 13 A88-16990
AAS PAPER 87-033 p. 103 A88-16993
AAS PAPER 87-035 p. 13 A88-16996 *
AAS PAPER 87-043 p. 51 A88-16998
AAS PAPER 87-044 p. 83 A88-16999 *
AAS PAPER 87-045 p. 84 A88-17000 *

AD-A184355 p. 36 N88-12546 #
AD-A184809 p. 100 N88-13375 #
AD-A185202 p. 59 N88-13376 #
AD-A185384 p. 27 N88-13377 #
AD-A185401 p. 27 N88-13294 #
AD-A185528 p. 28 N88-14121 #
AD-A186098 p. 29 N88-15000 #
AD-A186139 p. 29 N88-15001 #
AD-A186140 p. 29 N88-15002 #
AD-A186359 p. 29 N88-15003 #
AD-A187128 p. 107 N88-17587 #
AD-A187217 p. 90 N88-16009 #
AD-A187465 p. 167 N88-17713 #
AD-A188410 p. 31 N88-19483 #
AD-A190390 p. 75 A88-20350 *

AFGL-TR-86-0221 p. 100 N88-13375 #
AFGL-TR-87-0330 p. 75 A88-20950 *

AFIT/GSM/LSPA-87S-13 p. 107 N88-17587 #

AFOSR-87-1167TR p. 28 N88-14121 #
AFOSR-87-1171TR p. 27 N88-13377 #
AFOSR-87-1189TR p. 27 N88-13294 #
AFOSR-87-1196TR p. 29 N88-15003 #
AFOSR-87-1269TR p. 29 N88-15002 #
AFOSR-87-1290TR p. 29 N88-15001 #
AFOSR-87-1561TR p. 30 N88-18000 #

AIAA PAPER 86-1014 p. 55 A88-26043 * #
AIAA PAPER 87-2950 p. 91 A88-12571 #
AIAA PAPER 87-2952 p. 91 A88-12572 #
AIAA PAPER 87-3082 p. 104 A88-26210 * #
AIAA PAPER 87-3083 p. 100 A88-26211 #
AIAA PAPER 88-0010A p. 99 A88-22011 * #
AIAA PAPER 88-0064 p. 103 A88-22044 * #
AIAA PAPER 88-0066 p. 112 A88-22046 #
AIAA PAPER 88-0080 p. 3 A88-22083 #
AIAA PAPER 88-0116 p. 99 A88-22092 #
AIAA PAPER 88-0120 p. 110 A88-22093 * #
AIAA PAPER 88-0160 p. 113 A88-22113 #
AIAA PAPER 88-0302 p. 150 A88-22017 #

AIAA PAPER 88-0305 p. 0 A88-22073 * #
AIAA PAPER 88-0308 p. 163 A88-22010 #
AIAA PAPER 88-0375 p. 124 A88-22017 * #
AIAA PAPER 88-0389 p. 15 A88-22089 #
AIAA PAPER 88-0430 p. 95 A88-22325 #
AIAA PAPER 88-0432 p. 14 A88-22321 #
AIAA PAPER 88-0439 p. 150 A88-22023 #
AIAA PAPER 88-0442 p. 163 A88-22326 #
AIAA PAPER 88-0443 p. 69 A88-22329 #
AIAA PAPER 88-0445 p. 154 A88-22330 * #
AIAA PAPER 88-0451 p. 154 A88-22331 #
AIAA PAPER 88-0456 p. 86 A88-22332 * #
AIAA PAPER 88-0457 p. 113 A88-22333 * #
AIAA PAPER 88-0458 p. 124 A88-22334 * #
AIAA PAPER 88-0464 p. 31 A88-22342 #
AIAA PAPER 88-0467 p. 36 A88-22343 * #
AIAA PAPER 88-0469 p. 96 A88-22345 * #
AIAA PAPER 88-0471 p. 66 A88-22357 * #
AIAA PAPER 88-0472 p. 71 A88-22358 * #
AIAA PAPER 88-0473 p. 36 A88-22363 * #
AIAA PAPER 88-0530 p. 114 A88-22396 #
AIAA PAPER 88-0531 p. 113 A88-22397 * #
AIAA PAPER 88-0533 p. 113 A88-22398 * #
AIAA PAPER 88-0534 p. 113 A88-22399 #
AIAA PAPER 88-0535 p. 113 A88-22400 * #
AIAA PAPER 88-0540 p. 155 A88-22405 * #
AIAA PAPER 88-0543 p. 7 A88-22412 #
AIAA PAPER 88-0549 p. 3 A88-22484 #
AIAA PAPER 88-0552 p. 118 A88-22485 * #
AIAA PAPER 88-0554 p. 14 A88-22486 * #
AIAA PAPER 88-0571 p. 51 A88-22501 #
AIAA PAPER 88-0572 p. 51 A88-22502 #
AIAA PAPER 88-0574 p. 52 A88-22504 #
AIAA PAPER 88-0575 p. 52 A88-22505 * #
AIAA PAPER 88-0577 p. 52 A88-22507 * #
AIAA PAPER 88-0585 p. 8 A88-22512 * #
AIAA PAPER 88-0587 p. 116 A88-22513 #
AIAA PAPER 88-0588 p. 114 A88-22514 * #
AIAA PAPER 88-0589 p. 114 A88-22515 * #
AIAA PAPER 88-0590 p. 114 A88-22516 * #
AIAA PAPER 88-0727 p. 3 A88-22549 #
AIAA PAPER 88-0750 p. 163 A88-22567 #
AIAA PAPER 88-0767 p. 76 A88-27542 #
AIAA PAPER 88-0775 p. 115 A88-27535 #
AIAA PAPER 88-0883 p. 164 A88-27584 * #
AIAA PAPER 88-2206 p. 21 A88-32177 * #
AIAA PAPER 88-2207 p. 56 A88-32178 * #
AIAA PAPER 88-2225 p. 76 A88-32189 #
AIAA PAPER 88-2228 p. 8 A88-32190 * #
AIAA PAPER 88-2230 p. 21 A88-32193 * #
AIAA PAPER 88-2234 p. 21 A88-32197 * #
AIAA PAPER 88-2260 p. 21 A88-32225 * #
AIAA PAPER 88-2270 p. 22 A88-32226 * #
AIAA PAPER 88-2271 p. 57 A88-32227 #
AIAA PAPER 88-2272 p. 22 A88-32228 #
AIAA PAPER 88-2273 p. 22 A88-32229 #
AIAA PAPER 88-2287 p. 22 A88-32240 * #
AIAA PAPER 88-2311 p. 22 A88-32259 * #
AIAA PAPER 88-2316 p. 57 A88-32264 * #
AIAA PAPER 88-2340 p. 22 A88-32283 #
AIAA PAPER 88-2341 p. 8 A88-32284 #
AIAA PAPER 88-2353 p. 23 A88-32293 * #
AIAA PAPER 88-2354 p. 23 A88-32294 #
AIAA PAPER 88-2356 p. 23 A88-32295 #
AIAA PAPER 88-2360 p. 23 A88-32300 #
AIAA PAPER 88-2361 p. 23 A88-32301 #
AIAA PAPER 88-2370 p. 23 A88-32307 #
AIAA PAPER 88-2391 p. 24 A88-32323 * #
AIAA PAPER 88-2393 p. 24 A88-32325 * #
AIAA PAPER 88-2411 p. 24 A88-32330 * #
AIAA PAPER 88-2414 p. 97 A88-32391 #
AIAA PAPER 88-2438 p. 8 A88-32356 #
AIAA PAPER 88-2439 p. 24 A88-32358 #
AIAA PAPER 88-2446 p. 17 A88-31977 * #
AIAA PAPER 88-2449 p. 17 A88-31978 #
AIAA PAPER 88-2452 p. 125 A88-31979 #
AIAA PAPER 88-2453 p. 18 A88-31380 #
AIAA PAPER 88-2456 p. 125 A88-31381 #
AIAA PAPER 88-2459 p. 125 A88-31382 * #
AIAA PAPER 88-2460 p. 18 A88-31393 * #
AIAA PAPER 88-2461 p. 18 A88-31394 #
AIAA PAPER 88-2462 p. 6 A88-31395 * #
AIAA PAPER 88-2464 p. 18 A88-31397 #

AIAA PAPER 88-2465 p. 19 A88-31400 * #
AIAA PAPER 88-2467 p. 28 A88-32914 #
AIAA PAPER 88-2469 p. 29 A88-32961 * #
AIAA PAPER 88-2472 p. 19 A88-31404 * #
AIAA PAPER 88-2476 p. 95 A88-31380 * #
AIAA PAPER 88-2479 p. 19 A88-31391 #
AIAA PAPER 88-2480 p. 57 A88-32962 * #
AIAA PAPER 88-2482 p. 57 A88-32963 * #
AIAA PAPER 88-2483 p. 19 A88-31392 * #
AIAA PAPER 88-2484 p. 15 A88-31393 * #
AIAA PAPER 88-2485 p. 15 A88-31394 * #
AIAA PAPER 88-2486 p. 19 A88-31395 * #
AIAA PAPER 88-2487 p. 72 A88-31396 * #
AIAA PAPER 88-2488 p. 19 A88-31787 * #
AIAA PAPER 88-2489 p. 43 A88-31398 * #
AIAA PAPER 88-2490 p. 10 A88-31399 * #

AIAA-88-2475 p. 31 N88-19132 * #

ASME PAPER 87-GT-252 p. 62 A88-11134 #

B-207537 p. 162 N88-13881 #

BAC-37 p. 45 N88-14824 * #

BAE-SS-1109 p. 74 N88-17196 #
BAE-SS-1111 p. 74 N88-17880 #

BAE-TP-ADVA p. 61 N88-13883 #

BF-R-88-125-2 p. 132 N88-15384 #

BKTCH364 p. 28 N88-10367 #
BKTCHM31 p. 37 N88-11739 #

CERL-SRA-1023T-VOL-1 p. 126 N88-13308 * #
CERL-SRA-1023T-VOL-2 p. 126 N88-13887 * #
CERL-SRA-1023T-VOL-4 p. 126 N88-11886 * #

CERL-TA-M-87-16 p. 29 N88-15000 #
CERL-TA-M-87-17 p. 31 N88-19483 #

CONF-8704161-1 p. 87 N88-10340 #
CONF-871182-1 p. 88 N88-15457 * #

CR-R-016 p. 60 N88-16050 * #

CS-RP-A-015 p. 145 N88-10050 #
CS-RP-A-027 p. 146 N88-15035 #

CSDL-R-2012 p. 25 N88-10103 * #

CSDL-T-925 p. 58 N88-11856 * #

DC-87 p. 59 N88-13376 #

DE87-010899 p. 87 N88-10346 #
DE88-000244 p. 37 N88-11788 #
DE88-001821 p. 37 N88-13381 #
DE88-002366 p. 88 N88-15457 * #

DGLR-BERICHT-86-02 p. 160 A88-13443

DGLR-PAPER-87-077 p. 4 A88-32977

DPD-614-VOL-1 p. 104 N88-17721 * #
DPD-614-VOL-2-APP-D p. 66 N88-17724 * #
DPD-614-VOL-2-APP-E p. 40 N88-17723 * #
DPD-614-VOL-3 p. 66 N88-17722 * #
DPD-650-DR-5 p. 127 N88-15895 * #
DPD-654 p. 127 N88-14116 * #
DPD-685-VOL-1 p. 116 N88-10828 * #

DR-5 p. 66 N88-10367 * #
DR-4-VOL-2-APP-D p. 66 N88-17724 * #
DR-4-VOL-2-APP-E p. 66 N88-17723 * #
DR-4-VOL-3 p. 116 N88-10828 * #
DR-5-VOL-1 p. 104 N88-17721 * #
DR-5-VOL-3 p. 66 N88-17722 * #
DR-6 p. 127 N88-14116 * #

DRD-10-VOL-1 p. 126 N88-13388 * #
DRD-10-VOL-3 p. 126 N88-11887 * #

269

DRD-10-VOL-4 ..... p 126 [illegible] * #
DRD-10-VOL-4 ..... p 126 [illegible] * #

D160-27963-1-VOL-1 ..... p 104 [illegible] * #
D160-27963-2-VOL-2-APP-D ..... p 46 [illegible] * #
D160-27963-2-VOL-2-APP-E ..... p 46 [illegible] * #
D160-27963-2-VOL-2 ..... p 46 [illegible] * #
D160-30150-4 ..... p 25 [illegible] * #
D160-30158-1 ..... p 30 [illegible] * #

E-3310 ..... p 25 [illegible] * #
E-3353 ..... p 76 [illegible] * #
E-3358 ..... p 156 [illegible] * #
E-3464 ..... p 156 [illegible] * #
E-3732 ..... p 80 [illegible] * #
E-3736 ..... p 79 [illegible] * #
E-3777 ..... p 165 [illegible] * #
E-3825 ..... p 79 [illegible] * #
E-3910 ..... p 72 [illegible] * #
E-3912 ..... p 73 [illegible] * #
E-3956 ..... p 81 [illegible] * #
E-3957 ..... p 79 [illegible] * #
E-3961 ..... p 167 [illegible] * #
E-3979 ..... p 77 [illegible] * #
E-3981 ..... p 73 [illegible] * #
E-3999 ..... p 74 [illegible] * #
E-3961 ..... p 81 [illegible] * #
E-4105 ..... p 31 [illegible] * #
E-4027 ..... p 97 [illegible] * #

EP-21 ..... p 79 [illegible] * #

ESA-CR(P)-1919-VOL-1 ..... p 74 [illegible] #
ESA-CR(P)-1919-VOL-2 ..... p 74 [illegible] #
ESA-CR(P)-2397 ..... p 96 [illegible] #
ESA-CR(P)-2399 ..... p 145 [illegible] #
ESA-CR(P)-2398 ..... p 76 [illegible] #
ESA-CR(P)-2399 ..... p 96 [illegible] #
ESA-CR(P)-2401 ..... p 145 [illegible] #
ESA-CR(P)-2403-VOL-1 ..... p 97 [illegible] #
ESA-CR(P)-2403-VOL-2 ..... p 97 [illegible] #
ESA-CR(P)-2403-VOL-3 ..... p 97 [illegible] #
ESA-CR(P)-2412 ..... p 118 [illegible] #
ESA-CR(P)-2413 ..... p 97 [illegible] #
ESA-CR(P)-2414 ..... p 145 [illegible] #
ESA-CR(P)-2417 ..... p 9 [illegible] #
ESA-CR(P)-2427 ..... p 101 [illegible] #
ESA-CR(P)-2437-PT-4 ..... p 79 [illegible] #
ESA-CR(P)-2445 ..... p 101 [illegible] #
ESA-CR(P)-2452 ..... p 127 [illegible] #
ESA-CR(P)-2454 ..... p 132 [illegible] #
ESA-CR(P)-2460 ..... p 140 [illegible] #
ESA-CR(P)-2461 ..... p 150 [illegible] #
ESA-CR(P)-2479 ..... p 60 [illegible] #
ESA-CR(P)-2481 ..... p 31 [illegible] #
ESA-CR(P)-2487 ..... p 61 [illegible] #
ESA-CR(P)-2491-VOL-1 ..... p 147 [illegible] #
ESA-CR(P)-2493-VOL-1 ..... p 157 [illegible] #
ESA-CR(P)-2496 ..... p 34 [illegible] #
ESA-CR(P)-2506 ..... p 9 [illegible] #
ESA-CR(P)-2509-VOL-1 ..... p 60 [illegible] #
ESA-CR(P)-2509-VOL-2 ..... p 60 [illegible] #
ESA-CR(P)-2509-VOL-3 ..... p 60 [illegible] #
ESA-CR(P)-2536 ..... p 120 [illegible] #
ESA-CR(P)-2017 ..... p 97 [illegible] #

ESA-ITT-AO-1-1-834-85F ..... p 94 [illegible] #

ESA-ITT-RO-1-1988-85F ..... p 95 [illegible] #

ESA-SP-1080 ..... p 118 [illegible] #
ESA-SP-1092 ..... p 146 [illegible] #
ESA-SP-269 ..... p 117 [illegible] #
ESA-SP-272 ..... p 128 [illegible] #

ETN-87-90511 ..... p 74 [illegible] #
ETN-87-90512 ..... p 74 [illegible] #
ETN-87-90517 ..... p 146 [illegible] #
ETN-87-90520 ..... p 96 [illegible] #
ETN-87-90522 ..... p 145 [illegible] #
ETN-87-90530 ..... p 76 [illegible] #
ETN-87-90534 ..... p 96 [illegible] #
ETN-87-90536 ..... p 97 [illegible] #
ETN-87-90537 ..... p 97 [illegible] #
ETN-87-90538 ..... p 97 [illegible] #
ETN-87-90548 ..... p 118 [illegible] #
ETN-87-90549 ..... p 97 [illegible] #
ETN-87-90554 ..... p 145 [illegible] #
ETN-87-90601 ..... p 132 [illegible]
ETN-87-90626 ..... p 39 [illegible] #
ETN-87-90960 ..... p 117 [illegible] #
ETN-87-90968 ..... p 118 [illegible] #
ETN-87-90978 ..... p 145 [illegible] #
ETN-87-90979 ..... p 9 [illegible] #
ETN-87-90993 ..... p 76 [illegible] #
ETN-87-91291 ..... p 57 [illegible] #

ETN-88-90576 ..... p 147 [illegible] #
ETN-88-90866 ..... p 101 [illegible] #
ETN-88-91073 ..... p 146 [illegible] #
ETN-88-91074 ..... p 146 [illegible] #
ETN-88-91075 ..... p 146 [illegible] #
ETN-88-91076 ..... p 147 [illegible] #
ETN-88-91142 ..... p 101 [illegible] #
ETN-88-91149 ..... p 127 [illegible] #
ETN-88-91150 ..... p 132 [illegible] #
ETN-88-91154 ..... p 146 [illegible] #
ETN-88-91205 ..... p 60 [illegible] #
ETN-88-91256 ..... p 60 [illegible] #
ETN-88-91259 ..... p 73 [illegible] #
ETN-88-91271 ..... p 60 [illegible] #
ETN-88-91272 ..... p 119 [illegible] #
ETN-88-91279 ..... p 119 [illegible] #
ETN-88-91280 ..... p 156 [illegible] #
ETN-88-91291 ..... p 145 [illegible] #
ETN-88-91293 ..... p 117 [illegible] #
ETN-88-91300 ..... p 120 [illegible] #
ETN-88-91413 ..... p 146 [illegible] #
ETN-88-91416 ..... p 120 [illegible] #
ETN-88-91435 ..... p 60 [illegible] #
ETN-88-91436 ..... p 117 [illegible] #
ETN-88-91444 ..... p 73 [illegible] #
ETN-88-91445 ..... p 73 [illegible] #
ETN-88-91697 ..... p 31 [illegible] #
ETN-88-91703 ..... p 91 [illegible] #
ETN-94-91702-VOL-1 ..... p 147 [illegible] #
ETN-88-91704 ..... p 39 [illegible] #
ETN-88-91705 ..... p 9 [illegible] #
ETN-88-91709 ..... p 97 [illegible] #
ETN-88-91971 ..... p 128 [illegible] #

FOK-TR-R-86-030 ..... p 96 [illegible] #

FTT-REP-0001/SAAB ..... p 101 [illegible] #

GPO-76-650 ..... p 166 [illegible]
GPO-78-940 ..... p 166 [illegible] #
GPO-80-245 ..... p 166 [illegible] #

HEG-1986-1036-VOL-1 ..... p 157 [illegible] #

How10-12 ..... p 0 [illegible] * #

IAF PAPER 87-ST-07 ..... p 2 A88-10071 #
IAF PAPER 87-01 ..... p 1 A88-15801 #
IAF PAPER 87-02 ..... p 103 A88-15802 #
IAF PAPER 87-03 ..... p 131 A88-15803 #
IAF PAPER 87-04 ..... p 69 A88-15804 #
IAF PAPER 87-05 ..... p 34 A88-15805 #
IAF PAPER 87-07 ..... p 141 A88-15807 * #
IAF PAPER 87-08 ..... p 122 A88-15808 #
IAF PAPER 87-09 ..... p 136 A88-15809 #
IAF PAPER 87-100 ..... p 105 A88-15671 #
IAF PAPER 87-103 ..... p 103 A88-15672 * #
IAF PAPER 87-109 ..... p 137 A88-15673 #
IAF PAPER 87-105 ..... p 44 A88-15670 #
IAF PAPER 87-110 ..... p 109 A88-15680 #
IAF PAPER 87-107 ..... p 109 A88-15804 * #
IAF PAPER 87-13 ..... p 122 A88-15810 * #
IAF PAPER 87-14 ..... p 106 A88-15811 #
IAF PAPER 87-15 ..... p 135 A88-15812 #
IAF PAPER 87-17 ..... p 82 A88-15813 #
IAF PAPER 87-165 ..... p 137 A88-15825 #
IAF PAPER 87-194 ..... p 143 A88-15001 * #
IAF PAPER 87-196 ..... p 140 A88-15003 #
IAF PAPER 87-197 ..... p 2 A88-15004 * #
IAF PAPER 87-198 ..... p 77 A88-15805 #
IAF PAPER 87-199 ..... p 77 A88-15806 #
IAF PAPER 87-19 ..... p 106 A88-15814 * #
IAF PAPER 87-200 ..... p 77 A88-15827 #
IAF PAPER 87-210 ..... p 69 A88-15940 #
IAF PAPER 87-211 ..... p 162 A88-15944 * #
IAF PAPER 87-218 ..... p 103 A88-15946 * #
IAF PAPER 87-219 ..... p 123 A88-15948 #
IAF PAPER 87-222 ..... p 137 A88-15950 #
IAF PAPER 87-225 ..... p 68 A88-15952 #
IAF PAPER 87-228 ..... p 69 A88-15953 #
IAF PAPER 87-229 ..... p 69 A88-15954 * #
IAF PAPER 87-234 ..... p 69 A88-15958 * #
IAF PAPER 87-238 ..... p 34 A88-15960 * #
IAF PAPER 87-241 ..... p 39 A88-15962 #
IAF PAPER 87-242 ..... p 76 A88-15880 #
IAF PAPER 87-243 ..... p 69 A88-15884 #
IAF PAPER 87-245 ..... p 69 A88-15896 * #
IAF PAPER 87-248 ..... p 71 A88-15897 #
IAF PAPER 87-24 ..... p 82 A88-15816 * #
IAF PAPER 87-250 ..... p 69 A88-15969 #
IAF PAPER 87-251 ..... p 69 A88-15970 * #
IAF PAPER 87-252 ..... p 109 A88-15971 #
IAF PAPER 87-253 ..... p 69 A88-15972 #
IAF PAPER 87-256 ..... p 11 A88-15974 #
IAF PAPER 87-259 ..... p 82 A88-15817 * #

IAF PAPER 87-261 ..... p 140 A88-15976 #
IAF PAPER 87-27 ..... p 83 A88-15818 #
IAF PAPER 87-29 ..... p 135 A88-15821 #
IAF PAPER 87-305 ..... p 94 A88-15836 #
IAF PAPER 87-30 ..... p 83 A88-15822 #
IAF PAPER 87-312 ..... p 12 A88-15011 #
IAF PAPER 87-315 ..... p 12 A88-15012 #
IAF PAPER 87-316 ..... p 109 A88-15014 #
IAF PAPER 87-317 ..... p 12 A88-15015 #
IAF PAPER 87-318 ..... p 89 A88-15016 #
IAF PAPER 87-319 ..... p 12 A88-15017 #
IAF PAPER 87-31 ..... p 90 A88-15823 * #
IAF PAPER 87-320 ..... p 12 A88-15018 #
IAF PAPER 87-321 ..... p 12 A88-15019 #
IAF PAPER 87-322 ..... p 49 A88-15020 #
IAF PAPER 87-325 ..... p 76 A88-15021 * #
IAF PAPER 87-328 ..... p 69 A88-15029 * #
IAF PAPER 87-340 ..... p 13 A88-15038 #
IAF PAPER 87-343 ..... p 60 A88-15039 #
IAF PAPER 87-351 ..... p 49 A88-15041 #
IAF PAPER 87-353 ..... p 49 A88-15043 #
IAF PAPER 87-354 ..... p 49 A88-15044 #
IAF PAPER 87-355 ..... p 49 A88-15045 #
IAF PAPER 87-356 ..... p 13 A88-15046 #
IAF PAPER 87-35 ..... p 122 A88-15825 * #
IAF PAPER 87-364 ..... p 50 A88-15049 #
IAF PAPER 87-36 ..... p 102 A88-15826 * #
IAF PAPER 87-370 ..... p 137 A88-15052 #
IAF PAPER 87-373 ..... p 128 A88-15054 #
IAF PAPER 87-37 ..... p 135 A88-15827 #
IAF PAPER 87-38 ..... p 129 A88-15828 * #
IAF PAPER 87-390 ..... p 110 A88-15061 #
IAF PAPER 87-39 ..... p 123 A88-15829 #
IAF PAPER 87-412 ..... p 115 A88-15062 #
IAF PAPER 87-41 ..... p 152 A88-15833 #
IAF PAPER 87-42 ..... p 123 A88-15831 #
IAF PAPER 87-433 ..... p 50 A88-15065 * #
IAF PAPER 87-439 ..... p 105 A88-15097 * #
IAF PAPER 87-450 ..... p 110 A88-15112 * #
IAF PAPER 87-46 ..... p 1 A88-15832 * #
IAF PAPER 87-470 ..... p 139 A88-15110 #
IAF PAPER 87-47 ..... p 101 A88-15833 * #
IAF PAPER 87-495 ..... p 110 A88-15135 #
IAF PAPER 87-50 ..... p 110 A88-15836 #
IAF PAPER 87-50 ..... p 110 A88-15835 #
IAF PAPER 87-51 ..... p 11 A88-15836 * #
IAF PAPER 87-520 ..... p 152 A88-15140 #
IAF PAPER 87-527 ..... p 152 A88-15155 #
IAF PAPER 87-529 ..... p 152 A88-15151 #
IAF PAPER 87-535 ..... p 105 A88-15156 * #
IAF PAPER 87-53 ..... p 49 A88-15838 #
IAF PAPER 87-541 ..... p 152 A88-15159 #
IAF PAPER 87-542 ..... p 129 A88-15160 #
IAF PAPER 87-544 ..... p 152 A88-15162 #
IAF PAPER 87-545 ..... p 152 A88-15163 #
IAF PAPER 87-549 ..... p 39 A88-15164 * #
IAF PAPER 87-550 ..... p 152 A88-15167 #
IAF PAPER 87-553 ..... p 152 A88-15171 #
IAF PAPER 87-570 ..... p 153 A88-15182 #
IAF PAPER 87-571 ..... p 120 A88-15183 #
IAF PAPER 87-572 ..... p 120 A88-15196 #
IAF PAPER 87-576 ..... p 153 A88-15197 #
IAF PAPER 87-60 ..... p 161 A88-15840 * #
IAF PAPER 87-611 ..... p 160 A88-15211 #
IAF PAPER 87-622 ..... p 103 A88-15215 * #
IAF PAPER 87-629 ..... p 110 A88-15221 #
IAF PAPER 87-62 ..... p 135 A88-15841 #
IAF PAPER 87-631 ..... p 163 A88-15223 #
IAF PAPER 87-63 ..... p 135 A88-15842 #
IAF PAPER 87-64 ..... p 101 A88-15843 * #
IAF PAPER 87-650 ..... p 133 A88-15237 #
IAF PAPER 87-65 ..... p 102 A88-15844 * #
IAF PAPER 87-66 ..... p 134 A88-15845 #
IAF PAPER 87-670 ..... p 103 A88-15253 * #
IAF PAPER 87-67 ..... p 139 A88-15846 #
IAF PAPER 87-68 ..... p 105 A88-15847 #
IAF PAPER 87-72 ..... p 2 A88-15848 * #
IAF PAPER 87-74 ..... p 139 A88-15849 #
IAF PAPER 87-75 ..... p 135 A88-15850 #
IAF PAPER 87-76 ..... p 96 A88-15851 * #
IAF PAPER 87-77 ..... p 162 A88-15852 #
IAF PAPER 87-78 ..... p 139 A88-15853 #
IAF PAPER 87-79 ..... p 2 A88-15854 #
IAF PAPER 87-81 ..... p 102 A88-15855 * #
IAF PAPER 87-82 ..... p 123 A88-15856 * #
IAF PAPER 87-83 ..... p 139 A88-15857 #
IAF PAPER 87-84 ..... p 139 A88-15858 #
IAF PAPER 87-85 ..... p 123 A88-15859 * #
IAF PAPER 87-86 ..... p 127 A88-15860 #
IAF PAPER 87-87 ..... p 127 A88-15861 #
IAF PAPER 87-90 ..... p 96 A88-15862 * #
IAF PAPER 87-93 ..... p 103 A88-15864 #
IAF PAPER 87-94 ..... p 137 A88-15865 #
IAF PAPER 87-95 ..... p 127 A88-15866 #
IAF PAPER 87-97 ..... p 103 A88-15868 * #

def FMPER-87-06 ..... p 162 A88-15850 #
def FMPER-87-09 ..... p 163 A88-15870 * #

IFSI-88-3 ..... p 113 N88-13022 #
IFSI-87-2 ..... p 180 N88-13378 #
IFSI-87-4 ..... p 145 N88-13379 #
IFSI-87-6 ..... p 117 N88-13380 #

LR-MITT-164-1(1987) ..... p 73 N88-16165 #
LR-MITT-164-2(1987) ..... p 73 N88-16190 #

INPE-4282-PRE/1154 ..... p 62 N88-19572 #
INPE-4283-PRE/1155 ..... p 61 N88-19516 #

GAS-R-621 ..... p 58 N88-11740 #

ISSN 2-85439-170-5 ..... p 132 N88-11702

ISSN 0281-6809 ..... p 58 N88-11740 #
ISSN 0375-4265 ..... p 146 N88-16767 #
ISSN 0379-6566 ..... p 116 N88-13081 #
ISSN 0379-6566 ..... p 146 N88-16777 #
ISSN 0379-6566 ..... p 129 N88-19484 #
ITSN 0389-4010 ..... p 30 N88-17730 #
ISSN 0766-1522 ..... p 132 N88-11702
ISSN 079-6565 ..... p 117 N88-12131 #

ITS TR-256A-86 ..... p 76 N88-11020 #

JPL D-3722 ..... p 76 N88-12030 * #

JPRS-USP-87-003 ..... p 144 N88-13050 #
JPRS-USP-87-006 ..... p 146 N88-16363 #

L-16356 ..... p 28 N88-13386 * #
L-16361 ..... p 29 N88-14115 * #
L-16378 ..... p 25 N88-13670 * #
L-16411 ..... p 31 N88-19568 * #

LDN TM-86-2 ..... p 76 N88-12030 * #

LMSC-HEC TR D990215 ..... p 6 N88-19477 * #

LMSC-D071317 ..... p 46 N88-19567 * #

LMSC-F271319A vOL 2 ..... p 104 N88-19629 * #
LMSC-F271367 vOL 1 ..... p 104 N88-19571 * #

LPI TR-88-01 ..... p 121 N88-19588 * #

M 670-PT 1 ..... p 89 N88-16360 * #

MATRA-EPT-85-vT109-255-97 ..... p 145 N88-11201 #

MATRA-EPT-DT-vT187-120 ..... p 87 N88-12341 #
MATRA-EPT-DT-vT187-227 ..... p 87 N88-12342 #
MATRA-EPT-DT-vT187-228 ..... p 87 N88-12343 #

MBB-RAU-004-87 vOL 1 ..... p 147 N88-17689 #

MBB-RVD-RVDv SVS-REP ERNO-01 ..... p 61 N88-17719 #

MBB-TR-RS017-014-85 ..... p 97 N88-16624 #

MBB-UR-E 958-87 ..... p 99 A88-21991 #
MBB-UR-E 976-87 ..... p 142 A88-21989 #
MBB-UR-E 981-87 ..... p 142 A88-21991 #
MBB-UR-E 954-87 ..... p 125 A88-21990 #

MBB-UN 967-87 ..... p 52 A88-21992 #

MBB-/TE 843-87 ..... p 167 N88-17409 #

MBB-/TE 913-16-85 ..... p 61 N88-17719 #

MCR-86-1323-vOL-1 ..... p 127 N88-14119 * #
MCR-86-2601 vOL 4-APP A-RE v-1 ..... p 150 N88-19610 * #
MCR-86-2601 vOL 4-RE v-1 ..... p 150 N88-19609 * #
MCR-86-528 ..... p 4 N88-10071 * #
MCR-86-650-TASK 3 ..... p 31 N88-19561 * #
MCR-87-1339-vOL 4 ..... p 126 N88-11701 * #
MCR-87-1352 ..... p 127 N88-15895 * #
MCR-87-500 ..... p 60 N88-15208 * #
MCR-87-570 ..... p 76 N88-11753 * #

MDC-B5108-vOL 1 ..... p 4 N88-10067 * #
MDC-W5108-vOL 2 ..... p 4 N88-10148 * #
MDC-H5108-vOL 3 ..... p 4 N88-10049 * #

N-2315-NASA ..... p E7 N88-12362 * #

NAL TR-842 ..... p 30 N88-17730 #

NAS 1-15-189891 ..... p 58 N88-11700 * #
NAS 1-15-189940 ..... p 45 N88-14688 * #

NASA-1-15-181154 ..... p 76 N88-12013 * #
NASA-1-15-182216 ..... p 79 N88-11746 * #
NASA-1-15-182229 ..... p 72 N88-11745 * #
NASA-1-15-182230 ..... p 73 N88-12429 * #
NASA-1-15-182232 ..... p 79 N88-11750 * #
NASA-1-15-182244 ..... p 165 N88-11944 * #
NASA-1-15-182296 ..... p 77 N88-18605 * #
NASA-1-15-182325 ..... p 60 N88-16812 * #
NASA-1-15-182331 ..... p 31 N88-19585 * #
NASA-1-15-182333 ..... p 167 N88-20253 * #
NASA-1-15-182458 ..... p 157 N88-12927 * #
NASA-1-15-182481 ..... p 6 N88-14855 * #
NASA-1-15-182521 ..... p 135 N88-14957 * #
NASA-1-15-182575 ..... p 126 N88-13368 * #
NASA-1-15-182613 ..... p 26 N88-13887 * #
NASA-1-15-182650 ..... p 107 N88-18609 * #
NASA-1-15-182777 ..... p 69 N88-15816 * #
NASA-1-15-182781 ..... p 73 N88-15836 * #
NASA-1-15-182786 ..... p 74 N88-17715 * #
NASA-1-15-182788 ..... p 61 N88-17726 * #
NASA-1-15-182821 ..... p 31 N88-19582 * #
NASA-1-15-182839 ..... p 97 N88-16734 * #
NASA-1-15-4016 ..... p 28 N88-13388 * #
NASA-1-15-4034 ..... p 31 N88-19568 * #
NASA-1-15-87619 ..... p 150 N88-11402 * #
NASA-1-15-88693 ..... p 25 N88-10121 * #
NASA-1-15-89117 ..... p 150 N88-14116 * #
NASA-1-15-89136 ..... p 62 N88-19575 * #
NASA-1-15-89180 ..... p 69 N88-15818 * #
NASA-1-15-89437 ..... p 156 N88-19594 * #
NASA-1-15-89726 ..... p 92 N88-17999 * #
NASA-1-15-89811 ..... p 69 N88-15817 * #
NASA-1-21-704A(05) ..... p 5 N88-13382 *
NASA-1-26-172508 ..... p 4 N88-10071 * #
NASA-1-26-172509-vOL-1 ..... p 166 N88-14855 * #
NASA-1-26-172509-vOL-2 ..... p 166 N88-14874 * #
NASA-1-26-172510 ..... p 126 N88-13368 * #
NASA-1-26-172511 ..... p 126 N88-11687 * #
NASA-1-26-172512 ..... p 126 N88-11686 * #
NASA-1-26-172513 ..... p 156 N88-12926 * #
NASA-1-26-172515 ..... p 25 N88-10103 * #
NASA-1-26-172516 ..... p 117 N88-12501 * #
NASA-1-26-172517 ..... p 37 N88-12747 * #
NASA-1-26-172524 ..... p 117 N88-11737 * #
NASA-1-26-172526 ..... p 58 N88-10866 * #
NASA-1-26-172529 ..... p 126 N88-11741 * #
NASA-1-26-175368 ..... p 72 N88-11946 * #
NASA-1-26-177421 ..... p 44 N88-14625 * #
NASA-1-26-177422 ..... p 45 N88-14626 * #
NASA-1-26-177423 ..... p 44 N88-10491 * #
NASA-1-26-177466 ..... p 28 N88-13954 * #
NASA-1-26-178228 ..... p 31 N88-18941 * #
NASA-1-26-178345 ..... p 107 N88-19580 * #
NASA-1-26-178392 ..... p 58 N88-11735 * #
NASA-1-26-178417 ..... p 97 N88-15077 * #
NASA-1-26-179169 ..... p 25 N88-10570 * #
NASA-1-26-179180 ..... p 116 N88-10920 * #
NASA-1-26-179200 ..... p 4 N88-10046 * #
NASA-1-26-179201 ..... p 79 N88-10104 * #
NASA-1-26-179202 ..... p 4 N88-10067 * #
NASA-1-26-179203 ..... p 4 N88-10049 * #
NASA-1-26-179205 ..... p 26 N88-10866 * #
NASA-1-26-179206 ..... p 116 N88-11481 * #
NASA-1-26-179215 ..... p 79 N88-11753 * #
NASA-1-26-179216 ..... p 5 N88-12532 * #
NASA-1-26-179218 ..... p 117 N88-12533 * #
NASA-1-26-179227 ..... p 87 N88-12105 * #
NASA-1-26-179228 ..... p 116 N88-14113 * #
NASA-1-26-179237 ..... p 28 N88-14087 * #
NASA-1-26-179238 ..... p 127 N88-14116 * #
NASA-1-26-181371 ..... p 119 N88-14123 * #
NASA-1-26-181472 ..... p 98 N88-13898 * #
NASA-1-26-181473 ..... p 106 N88-13819 * #
NASA-1-26-181476 ..... p 156 N88-11736 * #
NASA-1-26-181489 ..... p 27 N88-12343 * #
NASA-1-26-181504 ..... p 76 N88-12030 * #
NASA-1-26-181537 ..... p 58 N88-12017 * #
NASA-1-26-181556 ..... p 58 N88-13374 * #
NASA-1-26-181602 ..... p 167 N88-17727 * #
NASA-1-26-182331 ..... p 98 N88-13808 * #
NASA-1-26-182338 ..... p 58 N88-13907 * #
NASA-1-26-182367 ..... p 98 N88-15196 * #
NASA-1-26-182390 ..... p 102 N88-16577 * #
NASA-1-26-182409 ..... p 37 N88-11823 * #
NASA-1-26-182413 ..... p 157 N88-15852 * #
NASA-1-26-182418 ..... p 97 N88-15082 * #
NASA-1-26-182426 ..... p 73 N88-16547 * #
NASA-1-26-182428 ..... p 25 N88-15830 * #
NASA-1-26-182427 ..... p 121 N88-19588 * #
NASA-1-26-182454 ..... p 97 N88-16079 * #
NASA-1-26-182456 ..... p 120 N88-16810 * #
NASA-1-26-182538 ..... p 74 N88-19000 * #
NASA-1-26-182561 ..... p 107 N88-19579 * #
NASA-1-26-182572 ..... p 107 N88-18606 * #
NASA-1-26-182602 ..... p 151 N88-20035 * #
NASA-1-26-182657 ..... p 10 N88-19648 * #
NASA-1-26-4038 ..... p 57 N88-10062 * #
NASA-1-26-4114 ..... p 6 N88-19477 * #
NASA-1-26-4123 ..... p 60 N88-16360 * #
NASA-1-26-89706 ..... p 98 N88-15497 * #
NASA-1-55-10901 ..... p 80 N88-15924 * #
NASA-1-55-2407 ..... p 32 N88-20235 * #
NASA-1-55-2446 ..... p 5 N88-10825 * #
NASA-1-55-2473 ..... p 156 N88-13094 * #
NASA-1-55-2476 ..... p 156 N88-12520 * #
NASA-1-55-2490 ..... p 26 N88-10870 * #
NASA-1-55-2492-PI-1 ..... p 89 N88-16360 * #
NASA-1-55-2496 ..... p 118 N88-15354 * #
NASA-1-55-2499 ..... p 157 N88-14623 * #
NASA-1-55-2500 ..... p 121 N88-17691 * #
NASA-1-60-2765 ..... p 79 N88-12138 * #
NASA-1-60-2767 ..... p 26 N88-14115 * #
NASA-1-61-1124 ..... p 95 N88-10117 * #
NASA-1-71-LAR-13724-1 ..... p 149 N88-23983 * #
NASA-1-77-20217 ..... p 147 N88-18182 * #

NASA-CASE-LAR-13724-1 ..... p 149 N88-23983 * #

NASA-CP-10001 ..... p 80 N88-15924 * #
NASA-CP-2407 ..... p 32 N88-20235 * #
NASA-CP-2446 ..... p 5 N88-10825 * #
NASA-CP-2473 ..... p 156 N88-13094 * #
NASA-CP-2476 ..... p 156 N88-12520 * #
NASA-CP-2490 ..... p 26 N88-10870 * #
NASA-CP-2492-PI-1 ..... p 89 N88-16360 * #
NASA-CP-2496 ..... p 118 N88-15354 * #
NASA-CP-2499 ..... p 157 N88-14623 * #
NASA-CP-2500 ..... p 121 N88-17691 * #

NASA-CR-172006 ..... p 4 N88-10071 * #
NASA-CR-172009-vOL-1 ..... p 166 N88-14855 * #
NASA-CR-172009-vOL-2 ..... p 166 N88-14874 * #
NASA-CR-172010 ..... p 126 N88-13368 * #
NASA-CR-172011 ..... p 126 N88-11687 * #
NASA-CR-172012 ..... p 126 N88-11686 * #
NASA-CR-172013 ..... p 156 N88-12926 * #
NASA-CR-172015 ..... p 25 N88-10103 * #
NASA-CR-172016 ..... p 117 N88-12501 * #
NASA-CR-172017 ..... p 37 N88-12747 * #
NASA-CR-172024 ..... p 117 N88-11737 * #
NASA-CR-172026 ..... p 58 N88-10866 * #
NASA-CR-172029 ..... p 126 N88-11741 * #
NASA-CR-175368 ..... p 72 N88-11946 * #
NASA-CR-177421 ..... p 44 N88-14625 * #
NASA-CR-177422 ..... p 45 N88-14626 * #
NASA-CR-177423 ..... p 44 N88-10491 * #
NASA-CR-177466 ..... p 28 N88-13954 * #
NASA-CR-178228 ..... p 31 N88-18941 * #
NASA-CR-178345 ..... p 107 N88-19580 * #
NASA-CR-178392 ..... p 58 N88-11735 * #
NASA-CR-178417 ..... p 97 N88-15077 * #
NASA-CR-179169 ..... p 25 N88-10570 * #
NASA-CR-179180 ..... p 116 N88-10920 * #
NASA-CR-179200 ..... p 4 N88-10046 * #
NASA-CR-179201 ..... p 79 N88-10104 * #
NASA-CR-179202 ..... p 4 N88-10067 * #
NASA-CR-179203 ..... p 4 N88-10049 * #
NASA-CR-179205 ..... p 26 N88-10866 * #
NASA-CR-179206 ..... p 116 N88-11481 * #
NASA-CR-179215 ..... p 79 N88-11753 * #
NASA-CR-179216 ..... p 5 N88-12532 * #
NASA-CR-179218 ..... p 117 N88-12533 * #
NASA-CR-179227 ..... p 87 N88-12105 * #
NASA-CR-179228 ..... p 116 N88-14113 * #
NASA-CR-179237 ..... p 28 N88-14087 * #
NASA-CR-179238 ..... p 127 N88-14116 * #

271

NASA-CR-179233 ..... p 80 N89-15036 * #
NASA-CR-179264 ..... p 104 N89-15829 * #
NASA-CR-179266 ..... p 127 N89-15895 * #
NASA-CR-179280 ..... p 80 N89-15835 * #
NASA-CR-179281 ..... p 30 N89-16782 *
NASA-CR-179287 ..... p 104 N89-16571 * #
NASA-CR-179288 ..... p 104 N89-17721 * #
NASA-CR-179270 ..... p 46 N89-16567 * #
NASA-CR-179272 ..... p 46 N89-17722 * #
NASA-CR-179273 ..... p 46 N89-17724 * #
NASA-CR-179274 ..... p 46 N89-17723 * #
NASA-CR-179276 ..... p 91 N89-17717 * #
NASA-CR-179291 ..... p 30 N89-17686 * #
NASA-CR-179293 ..... p 150 N89-16639 * #
NASA-CR-179294 ..... p 150 N89-16610 * #
NASA-CR-179308 ..... p 127 N89-16619 * #
NASA-CR-179309 ..... p 104 N89-16742 * #
NASA-CR-179489 ..... p 74 N89-16368 * #
NASA-CR-180404 ..... p 118 N89-14114 * #
NASA-CR-180473 ..... p 87 N89-12342 * #
NASA-CR-180502 ..... p 60 N89-12541 * #
NASA-CR-180604 ..... p 91 N89-17731 * #
NASA-CR-180954 ..... p 167 N89-19377 * #
NASA-CR-180975 ..... p 77 N89-16794 * #
NASA-CR-180980 ..... p 158 N89-18612 * #
NASA-CR-181306 ..... p 25 N89-10240 * #
NASA-CR-181371 ..... p 118 N89-14123 * #
NASA-CR-181472 ..... p 96 N89-10896 * #
NASA-CR-181473 ..... p 106 N89-10919 * #
NASA-CR-181478 ..... p 106 N89-11736 * #
NASA-CR-181499 ..... p 27 N89-12343 * #
NASA-CR-181504 ..... p 78 N89-12030 * #
NASA-CR-181537 ..... p 59 N89-12917 * #
NASA-CR-181556 ..... p 59 N89-13374 * #
NASA-CR-181602 ..... p 167 N89-17727 * #
NASA-CR-182331 ..... p# N89-13908 * #
NASA-CR-182336 ..... p 59 N89-13907 * #
NASA-CR-182367 ..... p 66 N89-15196 * #
NASA-CR-182380 ..... p 102 N89-16577 * #
NASA-CR-182409 ..... p 37 N89-15923 * #
NASA-CR-182413 ..... p 157 N89-15952 * #
NASA-CR-182418 ..... p 97 N89-15092 * #
NASA-CR-182424 ..... p 73 N89-16547 * #
NASA-CR-182426 ..... p 29 N89-15830 * #
NASA-CR-182427 ..... p 121 N89-19546 * #
NASA-CR-182454 ..... p 87 N89-16879 * #
NASA-CR-182456 ..... p 120 N89-16810 * #
NASA-CR-182539 ..... p 74 N89-19000 * #
NASA-CR-182561 ..... p 107 N89-19379 * #
NASA-CR-182572 ..... p 107 N89-18606 * #
NASA-CR-182602 ..... p 151 N89-20005 * #
NASA-CR-182657 ..... p 10 N89-19646 * #
NASA-CR-4098 ..... p 57 N89-10362 * #
NASA-CR-4114 ..... p 6 N89-19477 * #
NASA-CR-4123 ..... p 60 N89-18360 * #

NASA-PAM-509/9.87 ..... p 165 N89-10072 * #

NASA-RP-1124 ..... p 95 N89-10117 * #

NASA-SP-7094(03) ..... p 5 N89-13362 *

NASA-TM-100031 ..... p 58 N89-11750 * #
NASA-TM-100040 ..... p 45 N89-14698 * #
NASA-TM-100154 ..... p 76 N89-13513 * #
NASA-TM-100216 ..... p 79 N89-11746 * #
NASA-TM-100229 ..... p 72 N89-11745 * #
NASA-TM-100230 ..... p 73 N89-12429 * #
NASA-TM-100232 ..... p 79 N89-11750 * #
NASA-TM-100244 ..... p 165 N89-11944 * #
NASA-TM-100286 ..... p 77 N89-18805 * #
NASA-TM-100320 ..... p 33 N89-16812 * #
NASA-TM-100321 ..... p 31 N89-19585 * #
NASA-TM-100329 ..... p 167 N89-20253 * #
NASA-TM-100458 ..... p 157 N89-12927 * #
NASA-TM-100481 ..... p 8 N89-14899 * #
NASA-TM-100501 ..... p 106 N89-14907 * #
NASA-TM-100503 ..... p 126 N89-13369 * #
NASA-TM-100513 ..... p 28 N89-10867 * #
NASA-TM-100550 ..... p 107 N89-19608 * #
NASA-TM-100777 ..... p 88 N89-15816 * #
NASA-TM-100781 ..... p 73 N89-15838 * #
NASA-TM-100786 ..... p 74 N89-17715 * #
NASA-TM-100788 ..... p 81 N89-17728 * #
NASA-TM-100821 ..... p 31 N89-19582 * #
NASA-TM-100839 ..... p 97 N89-18734 * #
NASA-TM-4016 ..... p 29 N89-13388 * #
NASA-TM-4034 ..... p 31 N89-19589 * #
NASA-TM-87819 ..... p 150 N89-11402 * #
NASA-TM-88693 ..... p 25 N89-10121 * #
NASA-TM-89117 ..... p 150 N89-14116 * #
NASA-TM-89139 ..... p 42 N89-19575 * #
NASA-TM-89190 ..... p 89 N89-15819 * #
NASA-TM-89437 ..... p 158 N89-19094 * #
NASA-TM-89705 ..... p 88 N89-15437 * #
NASA-TM-89708 ..... p 92 N89-17999 * #

NASA-TM-89811 ..... p 66 N89-15917 * #

NASA-TP-2765 ..... p 79 N89-12536 * #
NASA-TP-2767 ..... p 28 N89-14115 * #

NASA-TT-20217 ..... p 147 N89-19182 * #

NBS/TN 1235 ..... p 92 N89-17999 * #

NBSIR 89-3712 ..... p 158 N89-18612 * #

NLR-MP-86027-U ..... p 26 N89-10387 #

NLR-TR-86055-U ..... p 37 N89-11739 #
NLR-TR-87023-L,PT.4 ..... p 79 N89-11072 #

NSWAD-87-160FS ..... p 165 N89-10883 #

PB87-220760 ..... p 165 N89-10883 #
PB89-101027 ..... p 102 N89-16577 * #
PB89-124773 ..... p 92 N89-17999 * #
PB89-126072 ..... p 167 N89-17727 * #
PB89-178653 ..... p 158 N89-18612 * #

PREPRINT 557 ..... p 118 N89-14336 #

PUB LAR-100-167 ..... p 165 N89-12422 #

REPT.31799 ..... p 10 N89-19695 * #
REPT-8680561 ..... p 5 N89-10829 * #
REPT-8780265 ..... p 100 N89-11407 * #
REPT-8780347 ..... p 95 N89-10117 * #
REPT-8880049 ..... p 121 N89-17691 * #

RI/RD-87-211 ..... p 60 N89-12541 * #

RP-FA-0003 ..... p 120 N89-16807 #

RP-2010-0000-DS-09 ..... p 31 N89-19700 #

RVD-RVDV-FR-AS-01 ..... p 127 N89-14120 #

S-HRG-100-326 ..... p 166 N89-14043 #

S-565 ..... p 157 N89-12927 * #
S-570 ..... p 157 N89-14623 * #

SAE PAPER 861754 ..... p 1 A88-10155 *
SAE PAPER 871342 ..... p 133 A88-14368
SAE PAPER 871411 ..... p 38 A88-21076
SAE PAPER 871412 ..... p 38 A88-21077 *
SAE PAPER 871413 ..... p 39 A88-21078 *
SAE PAPER 871415 ..... p 7 A88-21079
SAE PAPER 871416 ..... p 133 A88-21080
SAE PAPER 871417 ..... p 39 A88-21081 *
SAE PAPER 871419 ..... p 34 A88-21083 *
SAE PAPER 871421 ..... p 34 A88-21085
SAE PAPER 871423 ..... p 96 A88-21087 *
SAE PAPER 871425 ..... p 7 A88-21089 *
SAE PAPER 871427 ..... p 39 A88-21090
SAE PAPER 871428 ..... p 130 A88-21091 *
SAE PAPER 871429 ..... p 39 A88-21092
SAE PAPER 871430 ..... p 129 A88-21093
SAE PAPER 871432 ..... p 123 A88-21095
SAE PAPER 871433 ..... p 39 A88-21096 *
SAE PAPER 871435 ..... p 39 A88-21098
SAE PAPER 871442 ..... p 34 A88-21104
SAE PAPER 871446 ..... p 40 A88-21106 *
SAE PAPER 871447 ..... p 40 A88-21107 *
SAE PAPER 871448 ..... p 40 A88-21108 *
SAE PAPER 871449 ..... p 153 A88-21109
SAE PAPER 871450 ..... p 40 A88-21110
SAE PAPER 871451 ..... p 40 A88-21111 *
SAE PAPER 871452 ..... p 40 A88-21112 *
SAE PAPER 871453 ..... p 40 A88-21113 *
SAE PAPER 871454 ..... p 41 A88-21114
SAE PAPER 871456 ..... p 41 A88-21115 *
SAE PAPER 871457 ..... p 153 A88-21116
SAE PAPER 871464 ..... p 153 A88-21122 *
SAE PAPER 871465 ..... p 153 A88-21123
SAE PAPER 871468 ..... p 154 A88-21124 *
SAE PAPER 871469 ..... p 41 A88-21125 *
SAE PAPER 871470 ..... p 41 A88-21126 *
SAE PAPER 871471 ..... p 41 A88-21127 *
SAE PAPER 871473 ..... p 41 A88-21128
SAE PAPER 871474 ..... p 34 A88-21129 *
SAE PAPER 871475 ..... p 154 A88-21130 *
SAE PAPER 871476 ..... p 130 A88-21131 *
SAE PAPER 871483 ..... p 139 A88-21136
SAE PAPER 871487 ..... p 41 A88-21141
SAE PAPER 871488 ..... p 42 A88-21142 *
SAE PAPER 871489 ..... p 42 A88-21143 *
SAE PAPER 871490 ..... p 154 A88-21144 *
SAE PAPER 871491 ..... p 42 A88-21145
SAE PAPER 871492 ..... p 42 A88-21146 *
SAE PAPER 871493 ..... p 42 A88-21147 *

SAE PAPER 871496 ..... p 124 A88-21148
SAE PAPER 871497 ..... p 124 A88-21149
SAE PAPER 871499 ..... p 124 A88-21150 *
SAE PAPER 871505 ..... p 35 A88-21151 *
SAE PAPER 871506 ..... p 35 A88-21152 *
SAE PAPER 871507 ..... p 35 A88-21153 *
SAE PAPER 871508 ..... p 35 A88-21154
SAE PAPER 871509 ..... p 35 A88-21155 *
SAE PAPER 871510 ..... p 42 A88-21156 *
SAE PAPER 871512 ..... p 42 A88-21158 *
SAE PAPER 871514 ..... p 43 A88-21159
SAE PAPER 871515 ..... p 43 A88-21161
SAE PAPER 871517 ..... p 43 A88-21162
SAE PAPER 871518 ..... p 154 A88-21163
SAE PAPER 871519 ..... p 43 A88-21164
SAE PAPER 872429 ..... p 17 A88-30999 * #

SAE SP-687 ..... p 122 A88-15575

SAND-87-1216 ..... p 37 N89-11738 #
SAND-87-1443 ..... p 37 N89-13361 #

SAR-1 ..... p 10 N89-19648 * #

SAT88-0002 ..... p 127 N89-18619 * #

SAWE PAPER-1763 ..... p 29 N89-13388 * #

SE/LS/AP-33-994 ..... p 127 N89-14120 #

SN-WP-4000-DOC-8809/85/F ..... p 120 N89-16798 #

SNIAS-813-CA/TS ..... p 145 N89-10990 #
SNIAS-872-422-108 ..... p 73 N89-13814 #

SPE-706 ..... p 70 A89-21601
SPE-729 ..... p 84 A89-21631

SSL-16-87 ..... p 26 N89-10966 * #

SSS-86-0133 ..... p 30 N89-16792 *

STS-86-0302-14-VOL-1 ..... p 126 N89-13369 * #
STS-86-0302-2A-VOL-2 ..... p 126 N89-11687 * #
STS-86-0302-4-VOL-4 ..... p 126 N89-11686 * #

TA-75 ..... p 25 N89-10240 * #

TL-2689-ISS-1 ..... p 101 N89-19004 #

UCRL-97570 ..... p 68 N89-15457 * #

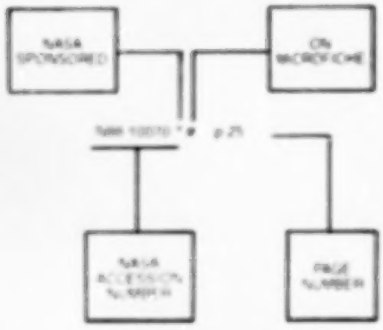
ULU-ENG-87-2260 ..... p 59 N89-13376 #

UPN-508 ..... p 25 N89-10103 * #
UPN-509 ..... p 58 N89-10966 * #

US-PATENT-APPL-SN-121678 ..... p 149 N89-23963 * #

UTRC-R87-917470-1 ..... p 96 N89-12546 #

Typical Accession Number Index Listing



Listings in this index are arranged alpha-numerically by accession number. The page number listed to the right indicates the page on which the citation is located. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

A88-10050 p 67
A88-10155 * p 1
A88-10366 * # p 159
A88-10367 # p 159
A88-10950 p 159
A88-10978 p 132
A88-10997 * # p 151
A88-10998 * # p 110
A88-11134 # p 62
A88-11234 p 107
A88-11235 p 67
A88-11726 * # p 109
A88-11734 * # p 32
A88-11776 p 63
A88-11782 * # p 63
A88-11793 * # p 63
A88-11794 * # p 63
A88-11795 # p 63
A88-11797 # p 63
A88-11798 * # p 64
A88-11799 * # p 64
A88-11800 * # p 64
A88-11801 * # p 64
A88-11802 # p 64
A88-11803 * # p 32
A88-11804 * # p 32
A88-11805 * # p 64
A88-11806 * # p 32
A88-11807 * # p 33
A88-11808 * # p 65
A88-11809 # p 33
A88-11810 # p 33
A88-11811 * # p 65
A88-11812 * # p 65
A88-11813 * # p 65
A88-11815 * # p 65
A88-11816 * # p 65
A88-11817 # p 65
A88-11822 # p 66
A88-11826 * # p 66
A88-11827 * # p 66
A88-11828 # p 66
A88-11829 * # p 67
A88-11830 * # p 66
A88-11831 # p 66
A88-11853 * # p 67
A88-11854 # p 67
A88-11855 # p 75
A88-11856 # p 67
A88-11857 # p 67
A88-11860 # p 67
A88-11861 * # p 67
A88-11863 * # p 67
A88-11865 * # p 75
A88-11870 * # p 68
A88-11874 # p 33
A88-11880 # p 106
A88-11881 # p 68
A88-11882 # p 68
A88-11908 # p 47
A88-11912 # p 75
A88-12006 * # p 33
A88-12526 p 61
A88-12571 # p 61
A88-12573 # p 61
A88-12591 * p 10
A88-12719 p 10
A88-12795 * p 94
A88-12813 * p 47
A88-12814 * p 47
A88-13126 p 1
A88-13162 p 39
A88-13164 * p 106
A88-13187 p 68
A88-13188 p 10
A88-13189 p 11
A88-13202 p 94
A88-13239 * p 94
A88-13443 p 160
A88-13444 # p 132
A88-13445 # p 160
A88-13446 # p 133
A88-13447 # p 160
A88-13448 # p 160
A88-13449 # p 133
A88-13450 # p 160
A88-13451 # p 160
A88-13452 # p 160
A88-13453 * # p 161
A88-13569 # p 133
A88-13572 # p 47
A88-13929 * p 11
A88-13932 * p 11
A88-13974 p 104
A88-13975 p 75
A88-14368 p 133
A88-14586 # p 48
A88-14911 p 133
A88-14980 p 33
A88-14995 p 48
A88-14996 p 82
A88-15276 p 161
A88-15277 p 11
A88-15278 p 11
A88-15279 p 133
A88-15280 p 48
A88-15282 * p 96
A88-15283 p 151
A88-15284 p 82
A88-15285 p 75
A88-15286 p 102
A88-15287 p 103
A88-15288 * p 121
A88-15289 p 82
A88-15290 * p 121
A88-15291 * p 121
A88-15292 * p 122
A88-15293 p 133
A88-15294 p 134
A88-15295 p 134
A88-15296 p 134
A88-15297 p 134
A88-15298 p 134
A88-15300 * p 82
A88-15303 * p 96
A88-15313 p 149
A88-15314 * p 1
A88-15348 p 151
A88-15476 p 134
A88-15480 # p 161
A88-15492 # p 68
A88-15511 # p 106
A88-15521 # p 122
A88-15575 p 122
A88-15650 p 135
A88-15664 p 68
A88-15801 # p 1
A88-15802 # p 106
A88-15803 # p 135
A88-15804 # p 68
A88-15805 # p 34
A88-15807 * # p 161
A88-15808 # p 122
A88-15809 # p 106
A88-15810 * # p 122
A88-15811 # p 106
A88-15812 # p 135
A88-15813 # p 82
A88-15814 * # p 106
A88-15816 * # p 82
A88-15817 * # p 82
A88-15819 # p 93
A88-15821 # p 135
A88-15822 # p 93
A88-15823 * # p 93
A88-15825 * # p 122
A88-15826 * # p 122
A88-15827 # p 135
A88-15828 * # p 109
A88-15829 # p 123
A88-15830 # p 152
A88-15831 # p 123
A88-15832 * # p 1
A88-15833 * # p 161
A88-15834 # p 109
A88-15835 # p 109
A88-15836 * # p 11
A88-15838 # p 48
A88-15840 * # p 161
A88-15841 # p 135
A88-15842 # p 135
A88-15843 * # p 161
A88-15844 * # p 162
A88-15845 # p 136
A88-15846 # p 136
A88-15847 # p 105
A88-15848 * # p 2
A88-15849 # p 136
A88-15850 # p 136
A88-15851 * # p 98
A88-15852 # p 162
A88-15853 # p 136
A88-15854 # p 2
A88-15855 * # p 162
A88-15856 * # p 123
A88-15857 # p 136
A88-15858 # p 136
A88-15859 * # p 123
A88-15860 # p 137
A88-15861 # p 137
A88-15863 * # p 98
A88-15864 # p 103
A88-15865 # p 137
A88-15866 # p 137
A88-15868 * # p 103
A88-15869 # p 162
A88-15870 * # p 103
A88-15871 # p 105
A88-15872 * # p 105
A88-15873 # p 137
A88-15874 # p 48
A88-15892 # p 109
A88-15894 * # p 109
A88-15895 # p 137
A88-15931 * # p 149
A88-15937 # p 149
A88-15934 * # p 2
A88-15935 # p 77
A88-15936 # p 77
A88-15937 # p 77
A88-15943 # p 48
A88-15944 * # p 162
A88-15946 * # p 123
A88-15949 # p 123
A88-15950 # p 137
A88-15951 # p 48
A88-15953 # p 69
A88-15954 * # p 69
A88-15958 * # p 69
A88-15960 * # p 34
A88-15963 # p 38
A88-15964 # p 69
A88-15966 * # p 69
A88-15967 # p 11
A88-15969 # p 69
A88-15970 * # p 69
A88-15971 # p 119
A88-15972 # p 69
A88-15974 # p 11
A88-15975 * # p 78
A88-15976 # p 149
A88-15989 # p 70
A88-16006 # p 94
A88-16011 # p 12
A88-16013 # p 12
A88-16014 # p 109
A88-16015 # p 12
A88-16016 # p 48
A88-16017 # p 12
A88-16018 # p 12
A88-16019 # p 12
A88-16020 # p 49
A88-16021 * # p 78
A88-16024 * # p 49
A88-16038 # p 13
A88-16039 # p 49
A88-16041 # p 49
A88-16043 # p 49
A88-16044 # p 49
A88-16045 # p 49
A88-16046 # p 13
A88-16049 # p 50
A88-16050 # p 137
A88-16054 # p 138
A88-16061 # p 110
A88-16071 # p 2
A88-16074 # p 162
A88-16082 # p 110
A88-16093 * # p 50
A88-16097 * # p 105
A88-16113 * # p 110
A88-16119 # p 138
A88-16138 # p 110
A88-16146 # p 162
A88-16150 # p 162
A88-16151 # p 152
A88-16156 * # p 105
A88-16159 # p 152
A88-16160 # p 129
A88-16162 # p 152
A88-16163 # p 152
A88-16166 * # p 38
A88-16167 # p 152
A88-16170 # p 152
A88-16182 # p 153
A88-16183 # p 129
A88-16186 # p 129
A88-16187 # p 153
A88-16211 # p 163
A88-16215 * # p 163
A88-16221 # p 110
A88-16223 # p 163
A88-16237 # p 105
A88-16243 * # p 163
A88-16276 p 50
A88-16280 p 50
A88-16281 p 50
A88-16285 p 110
A88-16292 p 13
A88-16293 p 13
A88-16294 p 110
A88-16295 p 2
A88-16296 p 50
A88-16308 * p 70
A88-16309 p 63
A88-16311 p 51
A88-16312 p 51
A88-16313 p 83
A88-16378 p 129
A88-16379 p 136
A88-16700 p 136
A88-16858 p 111
A88-16859 * p 111
A88-16860 p 111
A88-16866 * p 130
A88-16976 p 51
A88-16990 p 13
A88-16993 p 103
A88-16995 * p 13
A88-16998 p 51
A88-16999 * p 83
A88-17000 * p 84
A88-17023 p 70
A88-17026 * p 111
A88-17039 p 111
A88-17072 p 38
A88-17566 p 34
A88-17599 p 13
A88-17944 p 130
A88-18173 # p 14
A88-18223 p 138
A88-18230 * p 70
A88-18398 p 130
A88-18523 * p 70
A88-18632 # p 14
A88-18634 * # p 111
A88-18677 * # p 14
A88-18699 p 136
A88-18700 p 136
A88-19002 p 70
A88-19826 p 138
A88-19835 p 138
A88-19866 p 84
A88-19869 p 98
A88-19883 * p 111
A88-20038 p 112
A88-20054 p 139
A88-20067 p 112
A88-20282 * p 153
A88-20350 * p 75
A88-20457 p 139
A88-20475 p 123
A88-20486 * p 7
A88-20701 p 94
A88-20864 * p 153
A88-20908 p 14
A88-21076 p 39
A88-21077 * p 39
A88-21078 * p 39
A88-21079 p 7
A88-21080 p 103
A88-21081 * p 39
A88-21083 * p 34
A88-21085 p 34
A88-21087 * p 98
A88-21089 * p 7
A88-21090 p 39
A88-21091 * p 130

273

A88-21092 p 39
A88-21093 p 139
A88-21095 p 123
A88-21096 * p 39
A88-21098 p 39
A88-21104 p 34
A88-21106 * p 40
A88-21107 * p 40
A88-21108 * p 40
A88-21109 p 153
A88-21110 p 40
A88-21111 * p 40
A88-21112 * p 40
A88-21113 * p 40
A88-21114 p 41
A88-21115 * p 41
A88-21116 p 153
A88-21122 * p 153
A88-21123 p 153
A88-21124 * p 154
A88-21125 * p 41
A88-21126 * p 41
A88-21127 * p 41
A88-21128 p 41
A88-21129 * p 34
A88-21130 * p 154
A88-21131 * p 130
A88-21138 p 139
A88-21141 p 41
A88-21142 * p 42
A88-21143 * p 42
A88-21144 * p 154
A88-21145 p 42
A88-21146 * p 42
A88-21147 * p 42
A88-21148 p 124
A88-21149 p 124
A88-21150 * p 124
A88-21151 * p 35
A88-21152 * p 35
A88-21153 * p 35
A88-21154 p 35
A88-21155 * p 35
A88-21156 * p 42
A88-21158 * p 42
A88-21159 p 43
A88-21161 p 43
A88-21162 p 43
A88-21163 p 154
A88-21164 p 43
A88-21221 p 14
A88-21251 p 139
A88-21252 p 139
A88-21253 p 99
A88-21254 p 139
A88-21255 * p 78
A88-21256 p 139
A88-21257 p 99
A88-21521 # p 14
A88-21524 # p 140
A88-21531 * p 112
A88-21554 p 95
A88-21555 p 140
A88-21556 p 140
A88-21557 p 140
A88-21558 p 140
A88-21559 p 140
A88-21560 p 140
A88-21561 p 141
A88-21562 p 141
A88-21563 p 141
A88-21564 p 141
A88-21565 p 141
A88-21566 * p 2
A88-21567 p 141
A88-21568 p 112
A88-21569 p 2
A88-21570 p 154
A88-21572 p 2
A88-21573 p 142
A88-21574 p 142
A88-21575 p 142
A88-21601 p 70
A88-21605 * p 70
A88-21618 p 95
A88-21631 p 84
A88-21632 * p 84
A88-21633 p 71
A88-21634 p 84
A88-21635 p 43
A88-21637 p 124
A88-21638 p 84
A88-21639 * p 84
A88-21640 * p 85
A88-21641 p 71
A88-21642 * p 7
A88-21643 * p 7
A88-21644 * p 7
A88-21646 * p 85
A88-21647 * p 51
A88-21648 * p 85
A88-21649 * p 85
A88-21650 * p 99
A88-21651 * p 85
A88-21653 * p 124
A88-21654 p 99
A88-21655 p 85
A88-21656 * p 85
A88-21657 p 51
A88-21658 * p 112
A88-21659 * p 85
A88-22000 p 163
A88-22011 * # p 99
A88-22044 * # p 105
A88-22046 # p 112
A88-22063 # p 3
A88-22082 # p 99
A88-22083 * # p 112
A88-22113 # p 113
A88-22217 # p 150
A88-22253 * # p 3
A88-22255 # p 163
A88-22277 * # p 124
A88-22286 # p 14
A88-22320 # p 95
A88-22321 # p 14
A88-22323 # p 130
A88-22326 # p 163
A88-22329 # p 99
A88-22330 * # p 154
A88-22331 # p 154
A88-22332 * # p 86
A88-22333 * # p 113
A88-22334 * # p 124
A88-22342 # p 35
A88-22343 * # p 36
A88-22345 * # p 36
A88-22347 * # p 36
A88-22348 * # p 71
A88-22349 * # p 36
A88-22396 # p 113
A88-22397 * # p 113
A88-22398 * # p 113
A88-22399 # p 113
A88-22400 * # p 113
A88-22405 * # p 155
A88-22412 # p 7
A88-22484 # p 3
A88-22485 * # p 114
A88-22486 * # p 14
A88-22501 # p 51
A88-22502 # p 51
A88-22504 # p 52
A88-22505 * # p 52
A88-22507 * # p 52
A88-22512 * # p 8
A88-22513 # p 114
A88-22514 * # p 114
A88-22515 * # p 114
A88-22516 * # p 114
A88-22549 # p 3
A88-22567 # p 163
A88-22608 # p 15
A88-22609 # p 52
A88-22676 p 71
A88-22677 p 71
A88-22691 p 71
A88-22707 p 78
A88-22708 p 78
A88-22919 p 130
A88-22932 * p 52
A88-22933 * p 52
A88-22957 p 164
A88-23516 p 142
A88-23924 p 114
A88-23925 * p 164
A88-23930 p 131
A88-23981 # p 99
A88-23982 # p 52
A88-23989 # p 142
A88-23990 # p 125
A88-23991 # p 142
A88-24101 p 155
A88-24230 * p 86
A88-24239 * p 86
A88-24281 * p 53
A88-24454 p 114
A88-24506 # p 53
A88-24793 p 142
A88-24945 p 131
A88-24980 # p 142
A88-25368 p 36
A88-25797 p 53
A88-25854 p 53
A88-25890 * p 115
A88-25943 p 143
A88-25979 p 36
A88-26059 p 143
A88-26150 p 72
A88-26166 p 3
A88-26170 p 143
A88-26197 p 164
A88-26209 p 8
A88-26210 * # p 104
A88-26211 # p 100
A88-26356 # p 53
A88-26364 # p 150
A88-26420 p 104
A88-26687 p 115
A88-26688 p 115
A88-26985 p 95
A88-26975 # p 86
A88-27148 p 15
A88-27301 p 53
A88-27319 * p 15
A88-27325 p 15
A88-27355 * p 86
A88-27356 p 15
A88-27357 p 15
A88-27358 p 53
A88-27359 * p 16
A88-27364 * p 54
A88-27367 * p 54
A88-27377 p 16
A88-27395 p 16
A88-27397 p 54
A88-27401 p 16
A88-27402 p 54
A88-27404 * p 54
A88-27535 # p 115
A88-27542 # p 76
A88-27584 * # p 164
A88-27656 p 164
A88-27734 p 143
A88-27743 p 143
A88-27750 * # p 3
A88-27768 p 54
A88-27778 # p 125
A88-27779 # p 54
A88-27781 # p 115
A88-27838 p 115
A88-27886 # p 72
A88-27887 # p 150
A88-27888 # p 78
A88-27952 # p 143
A88-27954 p 164
A88-28042 # p 16
A88-28043 * # p 55
A88-28250 p 72
A88-28253 # p 55
A88-28257 # p 3
A88-28349 p 131
A88-28509 # p 16
A88-28623 p 131
A88-28856 p 143
A88-28864 p 108
A88-28974 p 115
A88-29104 p 155
A88-29106 p 143
A88-29107 p 164
A88-29134 * p 155
A88-29136 p 43
A88-29140 * p 155
A88-29141 p 155
A88-29195 p 143
A88-29196 * p 108
A88-29236 p 78
A88-29237 p 106
A88-29245 # p 144
A88-29410 p 164
A88-29474 p 16
A88-29585 p 95
A88-29720 p 16
A88-29725 p 17
A88-29815 * # p 17
A88-29819 * # p 17
A88-29820 * # p 100
A88-30076 p 144
A88-30115 p 144
A88-30169 p 144
A88-30185 p 144
A88-30189 p 100
A88-30317 # p 72
A88-30320 # p 36
A88-30999 * # p 17
A88-31274 p 86
A88-31378 p 17
A88-31377 * # p 17
A88-31378 # p 17
A88-31379 # p 125
A88-31380 # p 16
A88-31381 # p 125
A88-31382 * # p 125
A88-31383 * # p 16
A88-31384 # p 16
A88-31385 * # p 4
A88-31387 # p 16
A88-31388 * # p 16
A88-31389 * # p 16
A88-31390 * # p 95
A88-31391 # p 19
A88-31392 * # p 19
A88-31393 * # p 55
A88-31394 * # p 55
A88-31395 * # p 19
A88-31396 * # p 72
A88-31397 * # p 19
A88-31398 * # p 43
A88-31399 * # p 55
A88-31403 p 19
A88-31404 p 95
A88-31427 p 19
A88-31564 * # p 55
A88-31565 * # p 55
A88-31567 # p 19
A88-31570 * # p 20
A88-31573 p 20
A88-31574 # p 56
A88-31580 # p 20
A88-31586 # p 20
A88-31589 # p 20
A88-31594 # p 20
A88-31596 # p 56
A88-31597 * # p 21
A88-31600 # p 56
A88-31605 * # p 56
A88-32145 # p 56
A88-32176 p 21
A88-32177 * # p 21
A88-32178 * # p 56
A88-32189 # p 76
A88-32190 * # p 8
A88-32193 # p 21
A88-32197 * # p 21
A88-32225 # p 21
A88-32226 * # p 22
A88-32227 # p 57
A88-32228 # p 22
A88-32229 # p 22
A88-32240 * # p 22
A88-32259 * # p 22
A88-32264 * # p 57
A88-32283 # p 22
A88-32284 # p 8
A88-32293 * # p 23
A88-32294 # p 23
A88-32296 # p 23
A88-32300 # p 23
A88-32301 # p 23
A88-32307 # p 23
A88-32323 * # p 24
A88-32325 * # p 24
A88-32339 * # p 24
A88-32341 # p 57
A88-32355 # p 8
A88-32356 * # p 24
A88-32359 * # p 24
A88-32360 * # p 24
A88-32362 * # p 57
A88-32363 # p 57
A88-32476 * p 125
A88-32477 p 4
A88-32716 p 24
N88-10047 * # p 4
N88-10048 * # p 4
N88-10049 * # p 4
N88-10050 # p 144
N88-10051 # p 144
N88-10052 # p 144
N88-10070 * # p 25
N88-10071 * # p 4
N88-10072 * # p 165
N88-10079 # p 116
N88-10080 # p 145
N88-10081 # p 116
N88-10082 * # p 57
N88-10084 * # p 106
N88-10085 * # p 165
N88-10086 * # p 116
N88-10088 * # p 76
N88-10089 * # p 125
N88-10090 * # p 88
N88-10091 * # p 165
N88-10093 * # p 25
N88-10094 * # p 36
N88-10099 * # p 57
N88-10100 * # p 125
N88-10103 * # p 25
N88-10104 * # p 78
N88-10117 * # p 95
N88-10121 * # p 25
N88-10203 # p 96
N88-10205 # p 145
N88-10206 # p 96
N88-10220 # p 76
N88-10340 * # p 25
N88-10341 # p 87
N88-10342 # p 87
N88-10343 # p 87
N88-10346 # p 87
N88-10367 # p 26
N88-10489 # p 87
N88-10491 * # p 44
N88-10625 # p 116
N88-10626 # p 116
N88-10640 * # p 5
N88-10747 * # p 116
N88-10819 * # p 106
N88-10828 * # p 116
N88-10829 * # p 5
N88-10842 * # p 145
N88-10844 * # p 165
N88-10847 * # p 96
N88-10848 * # p 44
N88-10851 * # p 131
N88-10859 * # p 131
N88-10860 * # p 131
N88-10866 * # p 58
N88-10867 * # p 26
N88-10868 * # p 26
N88-10870 * # p 26
N88-10871 * # p 126
N88-10872 * # p 26
N88-10873 * # p 26
N88-10874 * # p 26
N88-10875 * # p 27
N88-10876 * # p 27
N88-10877 * # p 27
N88-10878 * # p 5
N88-10879 * # p 126
N88-10880 * # p 27
N88-10881 * # p 126
N88-10882 * # p 156
N88-10883 * # p 165
N88-10896 * # p 96
N88-10980 * # p 145
N88-10981 # p 8
N88-11072 # p 79
N88-11402 * # p 100
N88-11681 * # p 116
N88-11686 * # p 126
N88-11687 * # p 126
N88-11700 * # p 58
N88-11702 p 132
N88-11715 p 96
N88-11719 p 132
N88-11721 p 58
N88-11723 p 132
N88-11730 p 72
N88-11732 p 76
N88-11735 * # p 58
N88-11736 * # p 106
N88-11737 * # p 117
N88-11738 # p 37
N88-11739 # p 37
N88-11740 # p 58
N88-11741 * # p 126
N88-11745 * # p 72
N88-11746 * # p 79
N88-11750 * # p 79
N88-11753 * # p 79
N88-11944 * # p 165
N88-11948 * # p 72
N88-12030 * # p 76
N88-12105 * # p 87
N88-12131 # p 117
N88-12132 # p 165
N88-12133 # p 117
N88-12134 # p 76
N88-12135 # p 145
N88-12136 # p 145
N88-12138 # p 165
N88-12142 # p 117
N88-12252 * # p 44
N88-12258 * # p 44
N88-12267 * # p 44
N88-12342 * # p 87
N88-12343 * # p 27
N88-12422 # p 165

N88-12424 # p 166
N88-12425 # p 166
N88-12429 * # p 73
N88-12501 * # p 117
N88-12504 # p 37
N88-12520 * # p 156
N88-12521 * # p 156
N88-12522 * # p 156
N88-12523 * # p 156
N88-12525 * # p 156
N88-12527 * # p 156
N88-12528 * # p 79
N88-12529 * # p 86
N88-12530 * # p 79
N88-12532 * # p 5
N88-12533 * # p 117
N88-12534 p 58
N88-12535 p 59
N88-12538 * # p 79
N88-12541 * # p 80
N88-12546 # p 86
N88-12747 * # p 37
N88-12817 * # p 59
N88-12917 # p 145
N88-12926 * # p 156
N88-12927 * # p 157
N88-13294 # p 27
N88-13368 * # p 126
N88-13369 * # p 126
N88-13374 * # p 59
N88-13375 # p 100
N88-13376 # p 59
N88-13377 # p 27
N88-13378 # p 100
N88-13379 # p 145
N88-13380 # p 117
N88-13381 # p 37
N88-13382 * p 5
N88-13388 * # p 28
N88-13513 * # p 76
N88-13622 * # p 28
N88-13623 * # p 28
N88-13814 # p 73
N88-13860 # p 101
N88-13907 * # p 59
N88-13908 * # p 88
N88-13954 * # p 28
N88-14043 # p 166
N88-14044 # p 166
N88-14067 * # p 28
N88-14113 * # p 118
N88-14114 * # p 118
N88-14115 * # p 28
N88-14116 * # p 150
N88-14118 * # p 127
N88-14120 # p 127
N88-14121 # p 28
N88-14123 * # p 118
N88-14336 # p 118
N88-14623 * # p 157
N88-14625 * # p 44
N88-14626 * # p 45
N88-14654 p 166
N88-14855 * # p 166
N88-14856 * # p 45
N88-14864 * # p 101
N88-14866 * # p 59
N88-14868 * # p 157
N88-14869 * # p 73
N88-14870 * # p 101
N88-14872 * # p 60
N88-14873 * # p 5
N88-14874 * # p 166
N88-14876 * # p 88
N88-14883 * # p 77
N88-14884 * # p 101
N88-14890 * # p 132
N88-14898 * # p 45
N88-14907 * # p 106
N88-14999 * # p 8
N88-15000 # p 29
N88-15001 # p 29
N88-15002 # p 29
N88-15003 # p 29
N88-15004 # p 101
N88-15005 # p 146
N88-15006 * # p 60
N88-15077 * # p 97
N88-15082 * # p 97
N88-15084 # p 132
N88-15196 * # p 88
N88-15354 * # p 118
N88-15355 * # p 118
N88-15356 * # p 5
N88-15357 * # p 5
N88-15358 * # p 118
N88-15359 * # p 118
N88-15365 # p 157
N88-15497 * # p 86
N88-15603 * # p 119
N88-15618 * # p 9
N88-15620 * # p 119
N88-15622 * # p 9
N88-15631 * # p 119
N88-15816 * # p 86
N88-15817 * # p 86
N88-15818 * # p 89
N88-15822 # p 119
N88-15823 * # p 37
N88-15825 # p 60
N88-15826 # p 157
N88-15828 # p 38
N88-15829 * # p 104
N88-15830 * # p 29
N88-15835 * # p 60
N88-15838 * # p 73
N88-15852 * # p 157
N88-15895 * # p 127
N88-15924 * # p 60
N88-15925 * # p 60
N88-15930 * # p 127
N88-15931 * # p 150
N88-15932 * # p 60
N88-15933 * # p 60
N88-16060 * # p 60
N88-16063 # p 146
N88-16099 # p 60
N88-16189 # p 73
N88-16190 # p 73
N88-16264 # p 158
N88-16268 # p 119
N88-16298 # p 119
N88-16360 * # p 89
N88-16370 * # p 89
N88-16372 * # p 9
N88-16373 * # p 89
N88-16375 * # p 9
N88-16376 * # p 45
N88-16381 * # p 89
N88-16385 * # p 146
N88-16388 * # p 89
N88-16395 * # p 101
N88-16404 * # p 102
N88-16409 * # p 89
N88-16416 * # p 90
N88-16417 * # p 9
N88-16419 * # p 90
N88-16423 * # p 102
N88-16425 * # p 90
N88-16427 * # p 102
N88-16428 * # p 9
N88-16442 * # p 45
N88-16443 * # p 90
N88-16547 * # p 73
N88-16577 * # p 102
N88-16737 # p 90
N88-16767 # p 146
N88-16769 # p 127
N88-16773 # p 74
N88-16777 # p 146
N88-16778 # p 167
N88-16779 # p 119
N88-16780 # p 167
N88-16781 # p 120
N88-16782 # p 120
N88-16783 # p 120
N88-16784 # p 146
N88-16792 * p 30
N88-16794 * # p 77
N88-16798 # p 120
N88-16799 # p 146
N88-16800 # p 146
N88-16801 # p 146
N88-16802 # p 147
N88-16803 # p 60
N88-16804 # p 60
N88-16805 # p 60
N88-16807 # p 120
N88-16809 # p 9
N88-16810 * # p 120
N88-16812 * # p 30
N88-16824 # p 97
N88-16879 * # p 97
N88-17106 # p 74
N88-17179 * # p 45
N88-17223 * # p 61
N88-17239 * # p 9
N88-17242 * # p 90
N88-17254 * # p 90
N88-17258 * # p 102
N88-17287 * # p 90
N88-17289 * # p 91
N88-17270 * # p 91
N88-17272 * # p 91
N88-17273 * # p 91
N88-17274 * # p 91
N88-17279 * # p 91
N88-17480 # p 74
N88-17567 # p 107
N88-17683 p 30
N88-17686 * # p 30
N88-17689 # p 147
N88-17691 * # p 121
N88-17710 * # p 167
N88-17713 # p 167
N88-17715 * # p 74
N88-17717 * # p 81
N88-17719 # p 61
N88-17721 * # p 104
N88-17722 * # p 46
N88-17723 * # p 46
N88-17724 * # p 46
N88-17727 * # p 167
N88-17728 * # p 81
N88-17730 # p 30
N88-17731 * # p 81
N88-17858 # p 167
N88-17999 * # p 92
N88-18009 # p 30
N88-18068 * # p 74
N88-18182 * # p 147
N88-18606 * # p 107
N88-18608 * # p 107
N88-18609 * # p 150
N88-18610 * # p 150
N88-18612 * # p 156
N88-18614 # p 147
N88-18616 # p 61
N88-18619 * # p 127
N88-18734 * # p 97
N88-18742 * # p 104
N88-18750 # p 31
N88-18805 * # p 77
N88-18941 * # p 31
N88-18951 * # p 147
N88-19000 * # p 74
N88-19080 # p 46
N88-19094 * # p 156
N88-19377 * # p 167
N88-19379 * # p 107
N88-19477 * # p 6
N88-19478 * # p 6
N88-19479 * # p 6
N88-19480 * # p 6
N88-19481 * # p 6
N88-19483 # p 31
N88-19484 # p 126
N88-19485 # p 126
N88-19486 # p 151
N88-19487 # p 6
N88-19488 # p 61
N88-19489 # p 61
N88-19490 # p 121
N88-19491 # p 92
N88-19492 # p 147
N88-19493 # p 92
N88-19494 # p 61
N88-19496 * # p 126
N88-19499 * # p 151
N88-19500 # p 147
N88-19501 * # p 6
N88-19502 # p 92
N88-19503 * # p 126
N88-19504 # p 92
N88-19505 # p 92
N88-19506 # p 126
N88-19507 # p 92
N88-19509 # p 93
N88-19510 # p 126
N88-19511 # p 93
N88-19514 # p 62
N88-19515 # p 147
N88-19516 # p 62
N88-19517 # p 148
N88-19518 # p 93
N88-19520 # p 62
N88-19522 # p 148
N88-19526 * # p 121
N88-19527 # p 93
N88-19528 # p 126
N88-19529 # p 93
N88-19531 # p 62
N88-19532 # p 148
N88-19533 # p 148
N88-19535 # p 126
N88-19536 * # p 93
N88-19537 # p 94
N88-19538 # p 94
N88-19541 # p 129
N88-19566 * # p 121
N88-19567 * # p 46
N88-19568 * # p 31
N88-19571 * # p 104
N88-19572 # p 62
N88-19575 * # p 62
N88-19580 * # p 107
N88-19585 * # p 31
N88-19592 * # p 31
N88-19648 * # p 10
N88-19884 * # p 102
N88-19885 * # p 10
N88-19886 * # p 6
N88-19887 * # p 10
N88-19888 * # p 46
N88-19894 # p 148
N88-19895 # p 148
N88-19896 # p 148
N88-19920 # p 158
N88-19921 # p 158
N88-19929 # p 158
N88-19934 # p 132
N88-19942 # p 129
N88-19946 # p 159
N88-19947 # p 149
N88-19952 # p 159
N88-19964 * # p 159
N88-20005 * # p 151
N88-20235 * # p 32
N88-20253 * # p 167
N88-23983 * # p 149

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1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA SP-7056 (07)		

4. Title and Subtitle	5. Report Date
Space Station Systems A Bibliography with Indexes	December, 1988
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
	10. Work Unit No.
9. Performing Organization Name and Address National Aeronautics and Space Administration Washington, DC 20546	11. Contract or Grant No.
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address	14. Sponsoring Agency Code

15. Supplementary Notes

Compiled by Technical Library Branch and edited by Space Station Office, Langley Research Center, Hampton, Virginia.

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17. Key Words (Suggested by Authors(s))	18. Distribution Statement
Space Stations Space Platforms Space Technology Experiments Space Erectable Structures	Unclassified - Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price *
Unclassified	Unclassified	292	A13/HC

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